SYSTEMS TRAINING MANUAL

2/15/65

SATURN IB ORIENTATION

SPACE DIVISION
CHRYSLER
CORPORATION

CHRYSLER CORPORATION SPACE DIVISION

SATURN IB ORIENTATION

TRAINING MANUAL 851-0

This publication presents a brief descriptive summary of the Saturn IB vehicle and Chrysler Corporation's accomplishments in the missiles and space field.

The Saturn IB information presented herein is based on current plans for each of the stages. Although there may be design changes from vehicle to vehicle, the basic components, systems, and operating principles will remain similar to previous models.

PREPARED THROUGH JOINT EFFORTS OF

Personnel Department

Education and Development Branch

Systems Training Unit

Michoud Operations

AND

Engineering Communications Department

Technical Information Branch

Applied Communications Engineering Section

Huntsville Operations

Date: 15 February 1965

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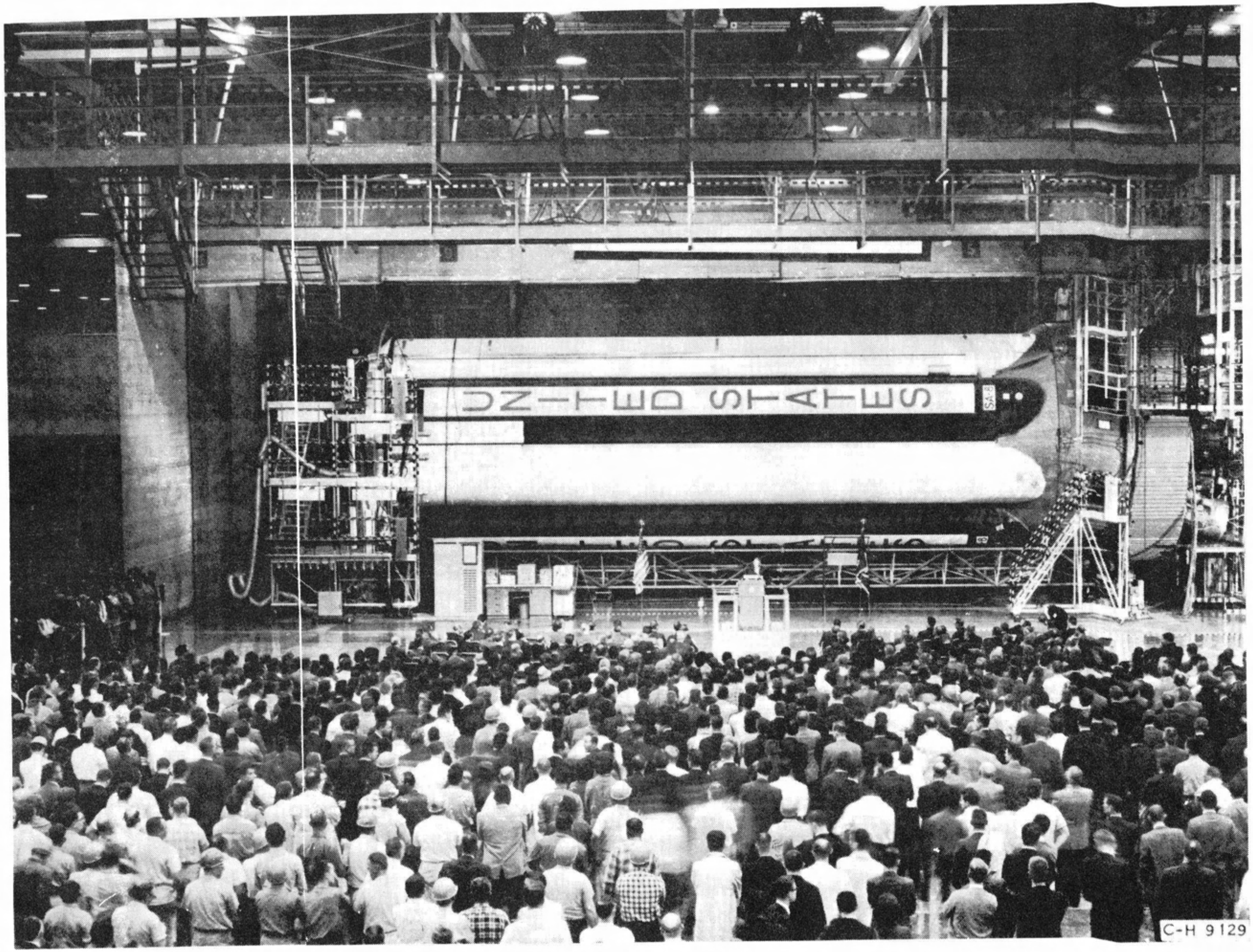

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SECTION I. INTRODUCTION

"... This book, Mr. Townsend, that you just gave me, is the inspection record of the bird behind me. It is full of stamps; stamps placed there by quality control inspectors, both from Chrysler and NASA, and this is probably just as it should be. We need quality control to make sure that nothing has been overlooked. But quality and reliability, two words that are heard so frequently ... are things that you cannot inspect into a rocket. They must be built into it. Quality and reliability are not, as some people seem to think, statistical tricks that are built into rockets by some computers in a remote location. Reliability and quality are rather the result of an almost religious dedication and devotion to perfection on the part of every member of the team.

I think you men and women of the Chrysler Corporation that have worked with us during these last years in the development and production of rockets have every reason to be proud. You have reason to be proud of this bird behind me; you have reason to be proud of this facility ...

... But you can also be proud of the general record that the Chrysler Corporation has established for itself in the rockets and space business. Chrysler was the first producer of an operational ballistic missile system in the country, the now obsolescent but still working Redstone. You established a 100 percent reliability record for yourselves in the assistance, in the development, and particularly in the production of the Jupiter intermediate range ballistic missile. You had a hand, a very important hand at that, in the establishment of the free world's first satellite, Explorer I, which is still in orbit today, many years after its injection. And finally, the world will never forget that it was Chrysler-built Redstones that gave our first astronauts, Alan Shepard and Gus Grissom, their first ride into outer space in a Mercury capsule. These were sub-orbital flights, but they paved the way for the orbital flights of men like John Glenn and Walter Schirra that were to follow.

No Chrysler missile has ever failed. I do not know if any other company can make such a proud statement about its own record. I wish you good luck and Godspeed for your future participation in this program ..."

Dr. Wernher von Braun, December 13, 1963

A. HISTORY

Dr. von Braun's remarks, as Director of the George C. Marshall Space Flight Center (MSFC), were made at the ceremony marking the completion of production of the first Chrysler-built Saturn I S-I stage and the presentation of the booster to the National Aeronautics and Space Administration (NASA) at the NASA-Michoud plant. His remarks are a thumbnail history of Chrysler's participation in the nation's missile and space effort and characterize our relationship with various governmental agencies over a good number of years.

As a result of Chrysler's exceptional World War II war effort under the leadership of K. T. Keller, on October 24, 1950 President Truman appointed Mr. Keller, president and chairman of the board of Chrysler Corporation, to the newly created position of Director of Guided Missiles for the U. S. Armed Forces. Shortly after his appointment to this position, with characteristic foresight, Mr. Keller insisted to the Chrysler board of directors that Chrysler enter the missile business. An Advanced Projects Group for missiles and space was formed within the Defense Division. This group later furnished the nuclei of both the Missile Division and the Space Division.

In the Summer of 1952, the Army Ballistic Missile Agency (ABMA) was seeking a prime contractor for the Redstone missile. Teams were sent to talk to the managements of various corporations that had the potential to become prime contractors. In October, 1952, the Department of Defense awarded Chrysler a contract to assist ABMA with the design and production of Redstone missiles. The jet engine plant that Chrysler had built during the Korean War for the Navy, and which had never been used because of contract cancellation, was converted into a missile manufacturing facility. Chrysler engineers were also integrated into important segments of the Redstone Arsenal at Huntsville, Alabama.

On September 29, 1954, Chrysler Corporation was granted the contract to produce the Redstone missile.

Mass production concepts stemming from automotive experience were employed by Chrysler in the development of fabrication and assembly operations for the Redstone. The Chrysler-operated Michigan Ordnance Missile Plant was the only one of its kind operated by a motor car manufacturer, and Chrysler is said to be the first U. S. missile builder to place large ballistic missiles in scheduled production. Chrysler made enormous strides in the development of facilities, methods, and tooling in the plant. The highly organized facility was complete with equipment for manufacturing, testing, quality control, and all the elements required to produce a missile ready for deployment to the armed forces. Moreover, a team called the Advance Projects Organization was formed within the Chrysler Defense Group to specialize in the concept and planning of new weapon and space system projects.

Because of Chrysler's close cooperation with Dr. von Braun and the ABMA team and Chrysler's proven success with the Redstone, Chrysler Corporation was granted the contract for the production of the Jupiter (IRBM) missile. By the time of the successful launch of the first Chrysler-built operational Jupiter on January 21, 1959, three months ahead of schedule, Chrysler Corporation was one of a handful of companies that could boast over six years of highly successful ballistic missile experiences. Today, no other firm has had -- or ever will have -- the opportunity to have so many of its personnel work with and learn the missile business under the guidance of Dr. von Braun and his staff. It is no wonder that Chrysler Corporation was chosen as the prime contractor for the Saturn I/IB space exploration booster.

1. Redstone. During the 1945-50 period of limited funds and limited sense of urgency, the Army built the facilities, assembled the talent, and accumulated the basic knowledge needed to produce its missile systems. At the White Sands Missile Range (then Proving Grounds, established in 1944) American and former German missilemen fired V-2's and other missiles under experimental conditions. Experimentation performed during those years emphasized the inseparability of missile and space research. The German V-2, an operational weapon, was used frequently as a space research vehicle. Army's Redstone developed in an opposite fashion. It was conceived as a test vehicle and, as the Jupiter C, performed many space exploration experiments including the launching of Explorer I.

The interrelation of missilry and space activities is personified by such scientists as Drs. von Braun, Stuhlinger, and their colleagues. During the 1920's and 1930's these men became interested in rockets and missiles solely as a means of exploring outer space. But the knowledge of rocketry they gained was adapted to military use, first by the German Army, then by the U. S. Army. When these space enthusiasts helped build the Jupiter C, they completed a cycle in their professional lives.

The first Redstone missile was built by the Army and fired in August, 1953, approximately two years after the first studies were initiated. Eleven more Redstones were built and tested by the Army. Missile 13, the first Chrysler-built Redstone, was delivered in November 1955.

The Redstone (Fig. 1) commonly referred to as the "father of American ballistic missiles" has had an unequaled record of successful firings. It was an Army Field Artillery Tactical Missile. As a weapon, it was considered to be a long-range surface-to-surface ballistic (projectile) type rocket. As a missile, it was considered to be a medium-range vehicle because it had a range of less than 500 miles.

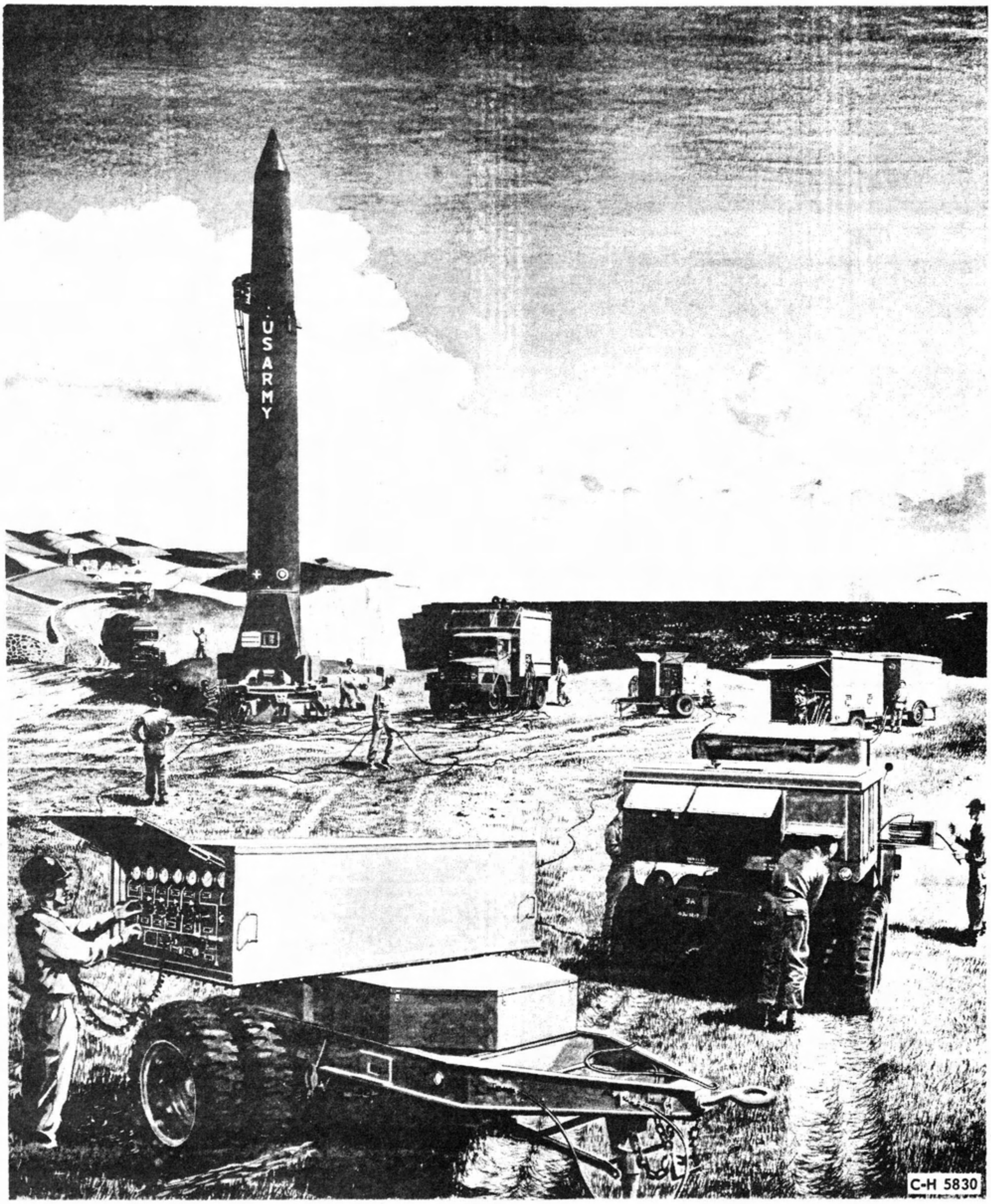

FIGURE 1. REDSTONE

The vehicle was powered by a single bipropellant liquid rocket engine developing 78,000 pounds of thrust. The missile was directed in flight from lift-off to impact by an inertial guidance and control system.

In addition to the Mercury-Redstone project, which is well known history, some of the highlights of the Redstone and Jupiter C program are shown in Table 1.

TABLE 1. REDSTONE AND JUPITER C HIGHLIGHTS

Missile	Event	Date Fired
1	First Redstone fired	20 August 1953
13	First Chrysler-built missile (delivered 14 November 1955)	19 July 1956
27	First deep penetration of space (Jupiter C)	20 September 1956
32	First Chrysler missile shipped directly to AMR	14 March 1957
40	First nose cone recovery (Jupiter C)	8 August 1957
42	First tactical top (warhead)	10 December 1957
29	Explorer I (Jupiter C)	31 January 1958
1002	First troop firing	16 May 1958
44	Explorer IV (Jupiter C)	26 July 1958
50 51	Hardtack (high altitude nuclear tests)	1 August 1958 12 August 1958

2. Jupiter. The Jupiter missile (Fig. 2) was an intermediate range ballistic missile (IRBM) conceived by the Army and designed to perform automatically the checkout, fueling, target alignment, ignition, and launch to the target within a specific time limit after the firing command was given. Approval for the development was granted by the Secretary of Defense on November 8, 1955. This approval was based on the experience gained by the Redstone Arsenal team from V-2 and Redstone. By this time, Chrysler

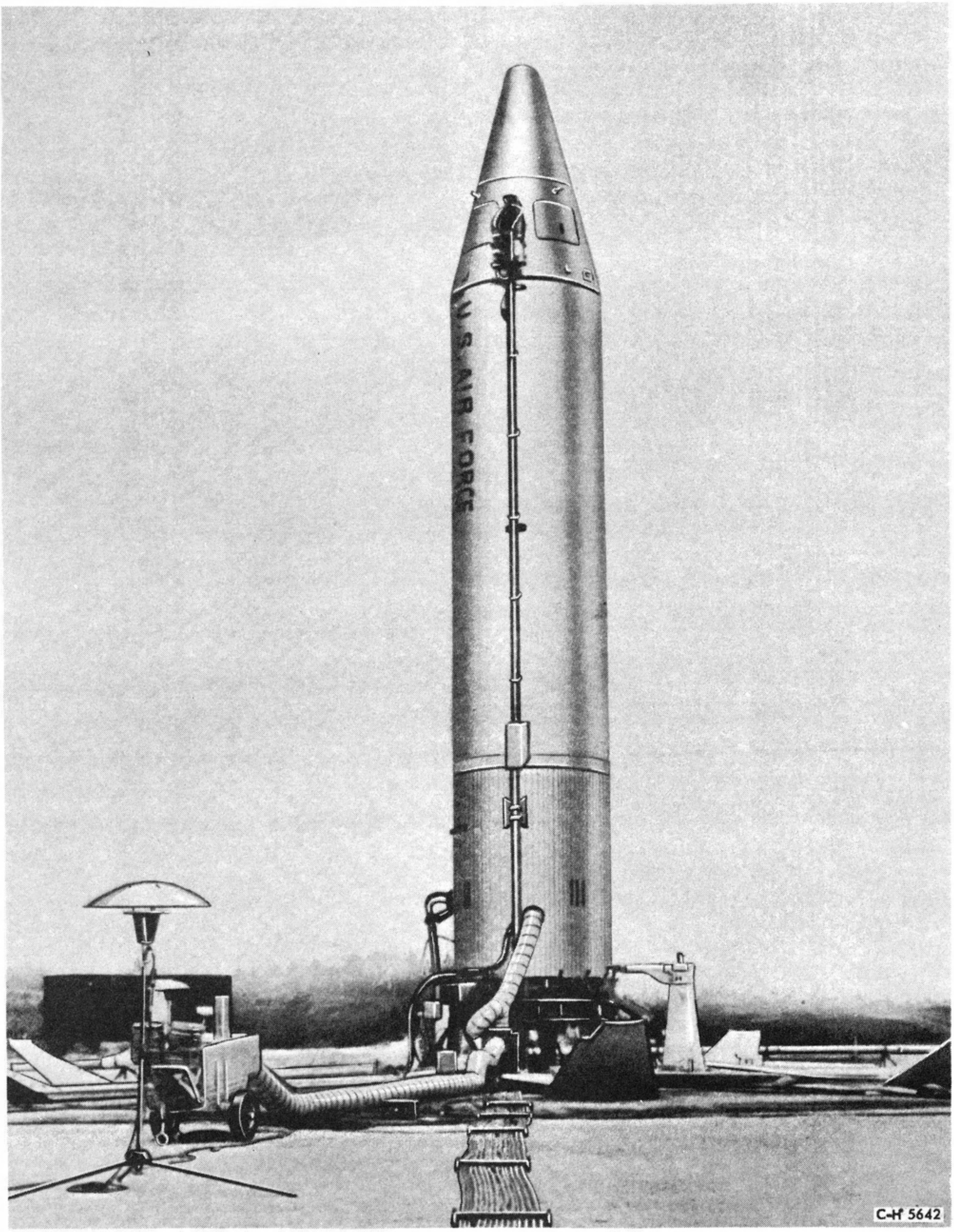

FIGURE 2. JUPITER

engineers had become well integrated members of this team and were participating directly in the design and development of this highly automated weapon system.

The first successful launching of an IRBM, the Army's Jupiter, was accomplished May 31, 1957. Chrysler Corporation continued to support the development work and was granted a contract early in 1958 for production of the Jupiter. On January 31, 1959, the first Chrysler-made operational Jupiter was launched. Because of a national defense policy change, all IRBM weapon systems (1500-mile range) were transferred to the Air Force. On May 6, 1959, a Chrysler-built Jupiter was successfully launched and declared operational by the USAF. The missile became the USAF Model SM-78 missile under the Air Force program.

ABMA continued its space exploration projects with modified Jupiters called Juno II. These missiles were used to launch Explorer, Pioneer, and Beacon satellites. Then, in April 1957, the scientific organization directed by Dr. von Braun began studies of launch vehicles having payloads of 20,000 to 40,000 pounds for orbital missions or 6,000 to 12,000 pounds for escape missions. In December 1957, the group submitted to the Department of Defense a "Proposal for a National Integrated Missile and Space Vehicle Development Program." This document indicated a need for a booster of 1,500,000 pounds thrust. In July 1958, representatives of the Advanced Research Projects Agency (ARPA) expressed interest in a clustered booster of 1,500,000 pounds thrust that would use rocket engines already tested and proven reliable. On August 15, 1958, ARPA Order 14-59 formally initiated what was to become the Saturn project.

3. Saturn I/IB. The order authorizing an R&D program for a large space vehicle booster specified that, to secure the desired thrust, a number of available rocket engines would be clustered, and the feasibility of this design would be demonstrated by a full-scale static firing by the end of 1959.

Early studies for the Saturn project had determined that an existing engine, the S-3D, used on both the Jupiter and Thor missiles, could be modified to produce an increased thrust of 188,000 pounds. Studies had also shown that the liquid oxygen (LOX) and fuel tanks developed for the Redstone and Jupiter missiles could, with some modification, be used for the tanks of the proposed booster. Thus, it was possible to begin booster development with certain well-tested hardware of proven reliability. As a result, the time for design and development of some important booster components and tooling was significantly shortened and the cost of hardware development and retooling reduced.

In October 1958, ARPA order 14-59 was amended to require the development of a reliable high-performance booster to serve as the first stage of a multistage vehicle capable of performing advanced space missions. ARPA also requested a study of a complete vehicle system so that upper-stage selection and development could begin and the launch facilities at the Atlantic Missile Range (AMR) could be determined.

In response to the ARPA order, construction of the ABMA static test stand for large boosters began on January 16, 1959 at Redstone Arsenal. By February 1959, a contract had been awarded for construction of the facilities at Launch Complex 34, and a design contract was also awarded for a movable service structure, which would be used to assemble and service the vehicle on the launch pad.

On February 3, 1959, an ARPA memorandum officially renamed the project Saturn, cancelling the former identification of Juno V.

During the early and middle part of 1959, numerous Saturn systems studies were presented to NASA and ARPA outlining various upper stage configurations. On November 18, 1959, NASA assumed technical direction of the Saturn project, pending its formal transfer from ARPA. On December 15, 1959, the Saturn Vehicle Evaluation Committee reached a decision on Saturn upper stage configurations. The committee, composed of representatives from NASA, ARPA, DOD, and USAF, recommended a long range development program for Saturn, including upper stage engines burning liquid hydrogen (LH_2) and LOX. The C-1 configuration, selected as the initial vehicle to be developed, was to be a stepping stone to the C-2 vehicle as shown in figure 3. A building-block concept was proposed that would yield a variety of Saturn configurations, each using previously proven developments as far as possible. As these recommendations were accepted by the NASA Administrator, December 31, 1959, a ten-vehicle R&D program was established. The C-1 configuration included the S-I, S-IV, and the S-V stages. The S-I stage was to have eight H-1 engines clustered, using LOX/RP-1 propellants capable of producing a total of 1,500,000 pounds of thrust. The S-IV stage was to have four engines using LOX/LH_2 propellants producing a total of 80,000 pounds of thrust. The S-V stage would use two of the same engines as the S-IV stage, producing a total of 40,000 pounds of thrust. The Saturn project was approved on January 1960, as a program of the highest national priority.

During March 1960, the executive order transferring the Saturn program to NASA became effective. After review of the S-IV proposals, Douglas Aircraft Corporation was awarded, on April 26, 1960, a contract to develop and build the stage, using six LH_2/LOX engines. On May 26, 1960 assembly of the booster for the first Saturn flight vehicle was begun. On July 1, 1960,

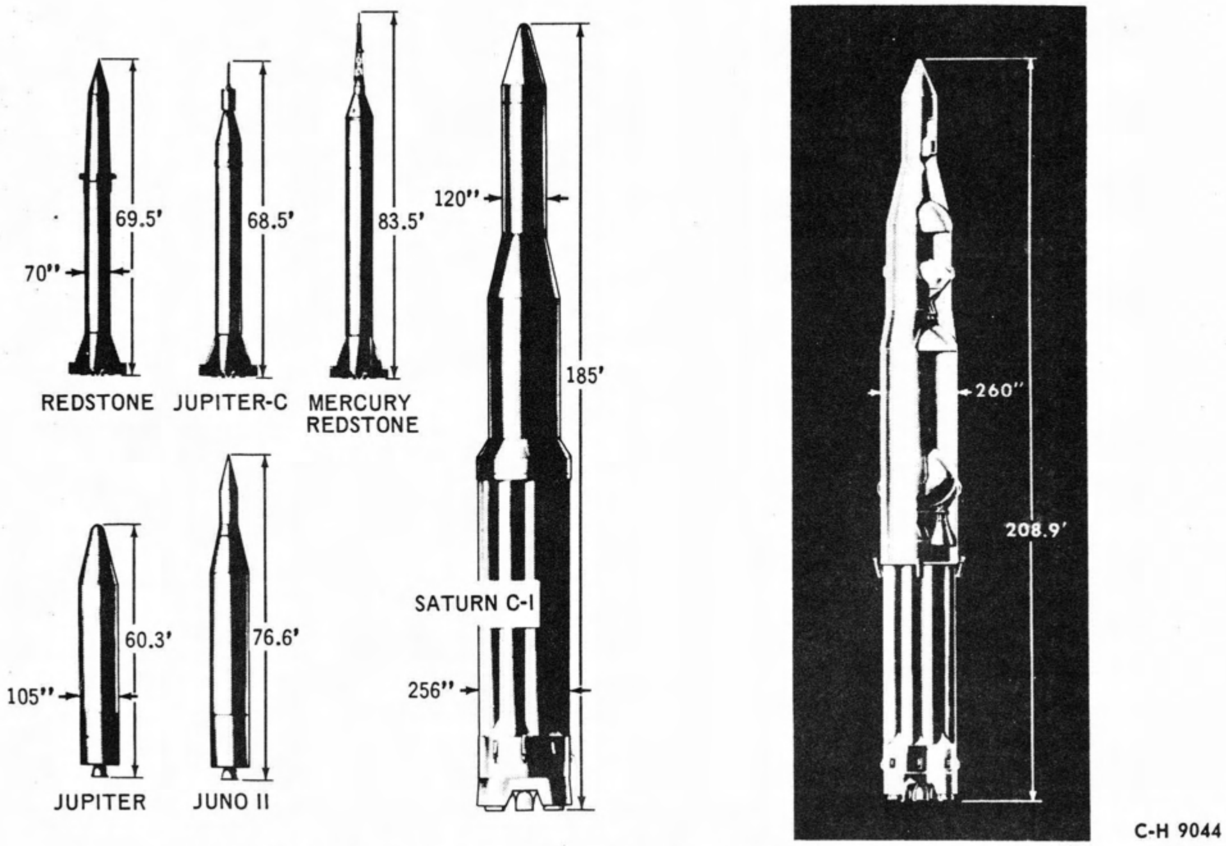

FIGURE 3. C-1, C-2, AND EARLIER VEHICLES

the Saturn program was formally transferred to the George C. Marshall Space Flight Center (MSFC).

In January 1961, Dr. von Braun proposed that the C-1 vehicle be changed from a three-stage to a two-stage configuration in support of the Apollo program. The change deleted requirements for the S-V stage on the C-1 vehicles. During May 1961, MSFC began re-examination of the capabilities of the Saturn C-2 configuration. Results of this examination indicated that, as lunar mission requirements had increased, a Saturn vehicle of even greater performance would be desirable. As a result of studies initiated at MSFC in May, Dr. von Braun announced, June 23, 1961, that further engineering design work on the C-2 configuration would be discontinued, and effort would instead be redirected toward clarification of the Saturn C-3 and Nova concepts. Investigations were specifically directed toward determining capabilities of the proposed C-3 configuration in supporting the Apollo mission.

During the period of Saturn development from 1958 to 1961, Chrysler engineers working with the von Braun team, though officially in support of the Redstone and Jupiter programs, were actively engaged in the development of the Saturn program. During the last week in June 1961, a contract was awarded to Chrysler Corporation for performance of qualification and reliability testing on various engine, hydraulic, mechanical, and structural components of the Saturn booster. This contract marked Chrysler's official entry into the Saturn program.

On September 7, 1961, the government-owned Michoud Ordnance Plant at New Orleans was selected by NASA as the site for industrial production of the S-I stage. The plant would be operated by industry under the technical direction of MSFC. Simultaneously, MSFC continued preparations for a conference to secure Requests for Quotations from industry on production of the S-I stage. On September 26, 1961, a proposal conference was held at New Orleans to secure bids for industrial production of the S-I stage, and on November 17, 1961, NASA announced the selection of Chrysler Corporation to negotiate a contract to build, check out, and test 20 S-I boosters. The contract was signed in mid-January 1962.

On July 11, 1962, NASA announced that a new two-stage Saturn class vehicle would be developed for manned earth orbital missions with full-scale Apollo spacecraft and associated equipment. The C-1 booster and the C-5 third stage would be adapted to provide a vehicle capable of performing these missions. This vehicle was identified as the Saturn C-IB. On August 6, 1962, NASA and Chrysler signed a contract for production of 21 C-1 boosters, with delivery to be made between late 1964 and early 1966. The stages would be produced by Chrysler at the Michoud Plant.

During the first week of February 1963, NASA announced that Saturn vehicle nomenclature had been changed from C-1 to Saturn I, from C-IB to Saturn IB, and from C-5 to Saturn V. On February 20, 1963, NASA approved the procurement plan for modification of the basic Chrysler contract, for redesigning the S-I stage to the S-IB configuration, and for the delivery of twelve S-IB stages and eight S-I stages. S-IB contract negotiations with Chrysler at Michoud were completed on August 5, 1963. In early November 1963, S-I-111 through S-I-116 stages were cancelled and existing hardware diverted to S-IB manufacture.

B. SATURN FAMILY AND MISSIONS

The Saturn IB is one of the Saturn launch vehicle family comprised of the four configurations shown in figure 4.

The four S-I Block I flight vehicles (SA-1 through SA-4) were used primarily to test and validate the multi-engine and clustered propellant tank concepts. These vehicles featured 165,000-pound thrust (165 K) engines and dummy upper stages. A simplified guidance system was used because of the limited trajectories flown by these vehicles.

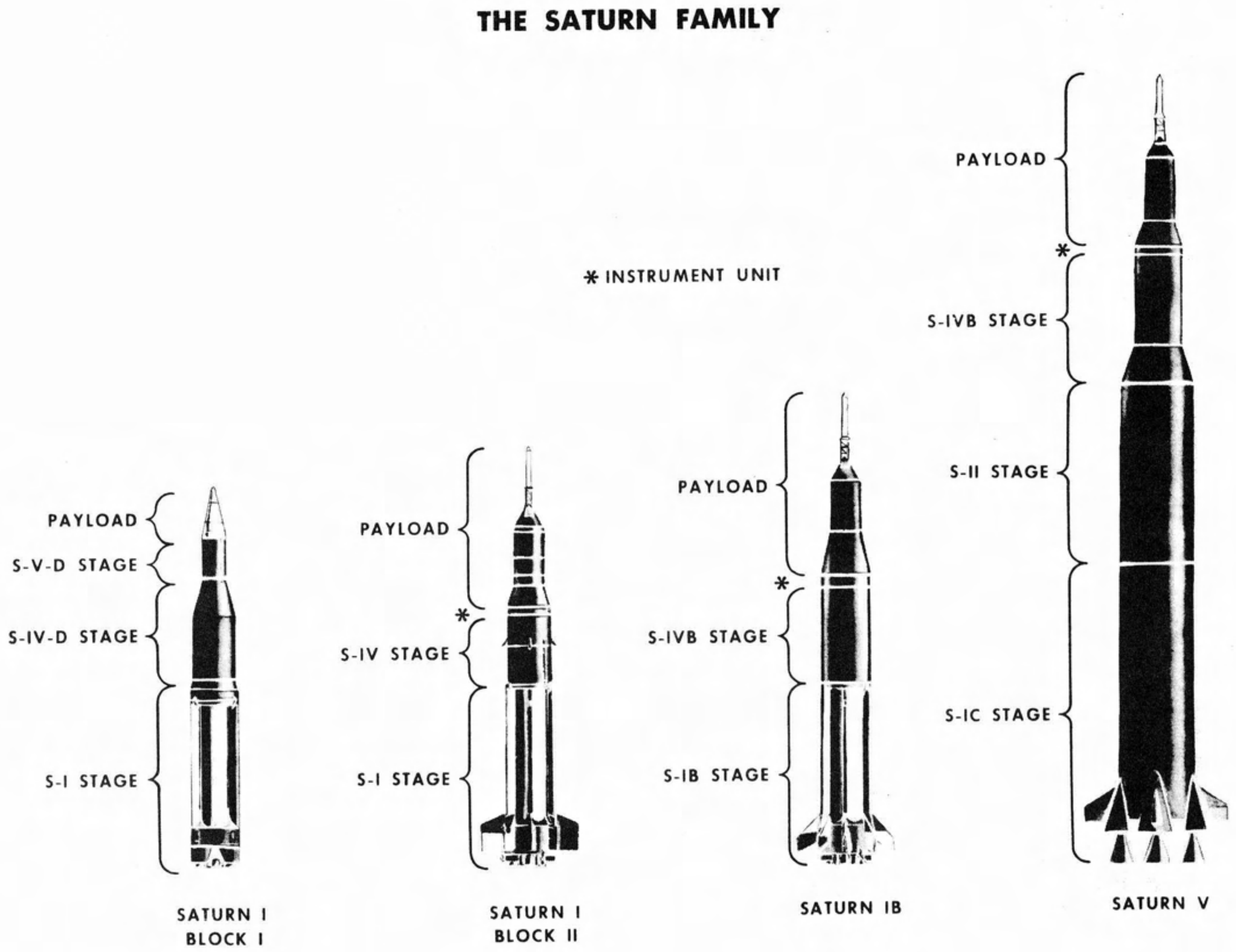

FIGURE 4. THE SATURN FAMILY OF VEHICLES

The Saturn I Block II flight vehicles (SA-5 through SA-10) have live second stages, instrument units, and are adapted for attachment of boiler-plate or prototype Apollo spacecraft. Engines for the S-I stage of the Block II vehicles are uprated to 188 K. Six LH_2/LOX fueled engines power the S-IV stage. These vehicles are being used to conduct performance tests of the integrated S-I/S-IV stages, prove the LH_2/LOX propellant combination, flight-test the prototype Apollo spacecraft, and conduct micrometeoroid measurement experiments.

The Saturn IB vehicle as shown represents the most advanced of a series of 22 Saturn I/IB test and flight vehicles to be produced. The flight versions of these vehicles incorporate components of the Saturn I and Saturn V vehicles. The eight engines used for the S-IB booster are rated at 200 K each; the S-IVB stage single LH_2/LOX fueled J-2 engine is rated at 200 K. The primary operational mission of the Saturn IB flight vehicles will be to place unmanned and manned Apollo spacecraft into earth orbits in accordance with specific mission requirements. A variety of tests will be conducted during these flights, including space docking and lunar landing maneuver exercises, and flight testing of the S-IVB stage for Saturn V and other heavier components of the Apollo program.

The Saturn V configuration shown in figure 4 is a multistage launch vehicle used for the Apollo manned lunar and planetary exploration program. Five engines, each with a thrust of 1,500,000 pounds and fueled with a mixture of RP-1-diesel and LOX, power the S-IC first stage of the launch vehicle. Engines, fueled with a mixture of LH_2 and LOX, power the S-II (second) stage, and the S-IVB (third) stage of the vehicle. An instrument unit is located between the S-IVB stage and the Apollo payload. The payload consists of the lunar excursion module (LEM), the service module (SM), and the command module (CM).

The Saturn I/IB vehicles are launched from two pads at AMR, launch complexes 34 and 37B. Saturn I Block I vehicles were launched from launch complex 34. This Complex has been modified and will be used to launch Saturn IB vehicles. Complex 37B is the launching site for the Saturn I Block II vehicles. It will be modified to launch Saturn IB vehicles. The launch complexes (Fig. 5) provide fuel, pneumatic, launch control center, service structure, launch pedestal, and umbilical tower facilities to erect and service the vehicle in preparation for launching.

Launching of the Saturn V will occur from Complex 39 at the AMR. The complex facilities provide the firing sites, vertical assembly building (VAB), launcher-umbilical tower (LUT), mobile arming tower, and crawler transporter for the assembly, checkout, transportation, and firing of the Saturn V vehicle. Because of the enormous size of the Saturn V, mating of the stages and checkout of the vehicle will be accomplished on the LUT in the VAB. The LUT with the erect, assembled vehicle will be then transported to the firing site by the crawler transporter.

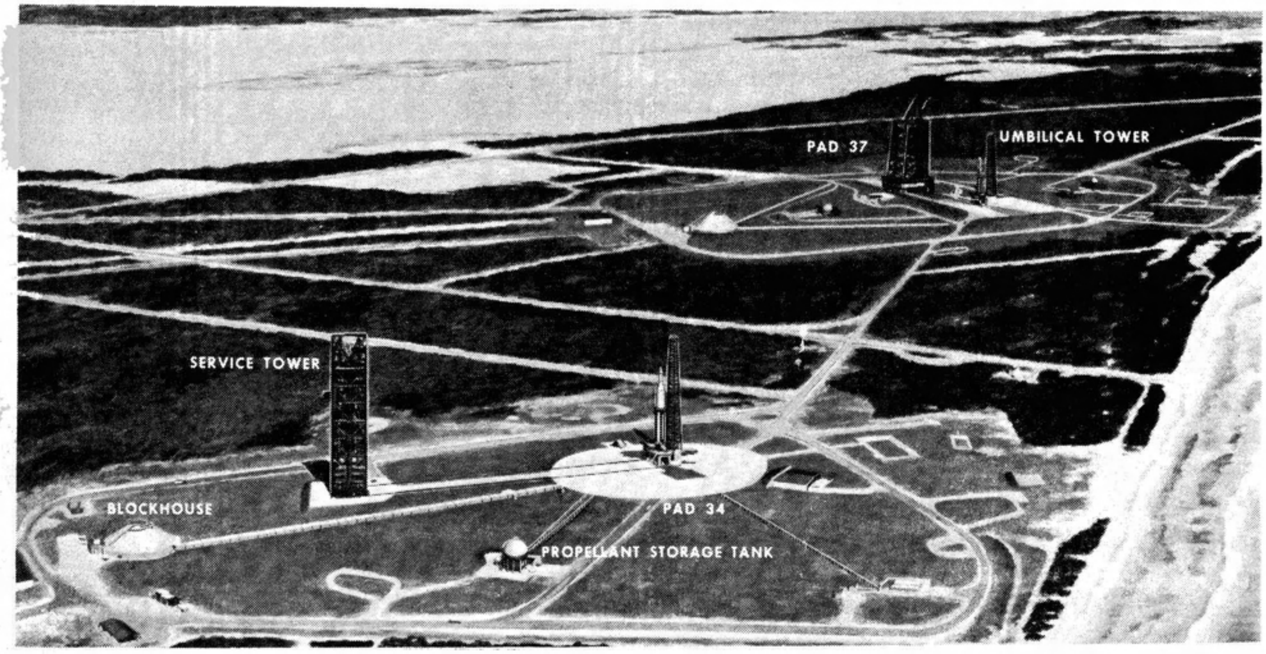

FIGURE 5. SATURN I/IB LAUNCH COMPLEXES

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SECTION II. CHRYSLER CORPORATION SPACE DIVISION

From its humble beginnings as an advanced projects working group in the Defense Division, Chrysler Corporation's missiles and space effort has evolved until it is two divisions (Missile Division and Space Division) within the Defense-Space Group. The Defense-Space Group has offices and facilities providing liaison and direct support of the major missiles and space facilities in the United States as shown in figure 6.

Our Washington, D. C. office maintains liaison with government agencies engaged in missiles and space activities and participates in contract negotiations at the program level.

The Detroit offices provide administrative support for the Defense-Space Group, provide direct engineering support to the Space and Missiles Divisions, and direct engineering support and liaison for the Lewis Research Center and Wright-Patterson Air Force Research Center.

Both the Missile and the Space Divisions maintain launch support operations at the Florida Operations plant at Cape Kennedy in engineering and technical support of both NASA and the Air Force. These operations participate in complex facility equipment installation, launch preparations, and refurbishing of launch complexes after launch.

The Houston office maintains liaison and engineering support for the Manned Space Center.

The White Sands office provides technical and engineering support for rocket and missile weapon systems testing conducted by the Army at the White Sands Missile Range.

The West Coast office maintains liaison with Edwards Air Force Base, Vandenburg Air Force Base, and manufacturing companies engaged in the missile and space business.

By far the largest of the organizations that compose the Space Division are the Michoud and Huntsville Operations engaged in engineering support and booster manufacture for MSFC and the Saturn I/IB project.

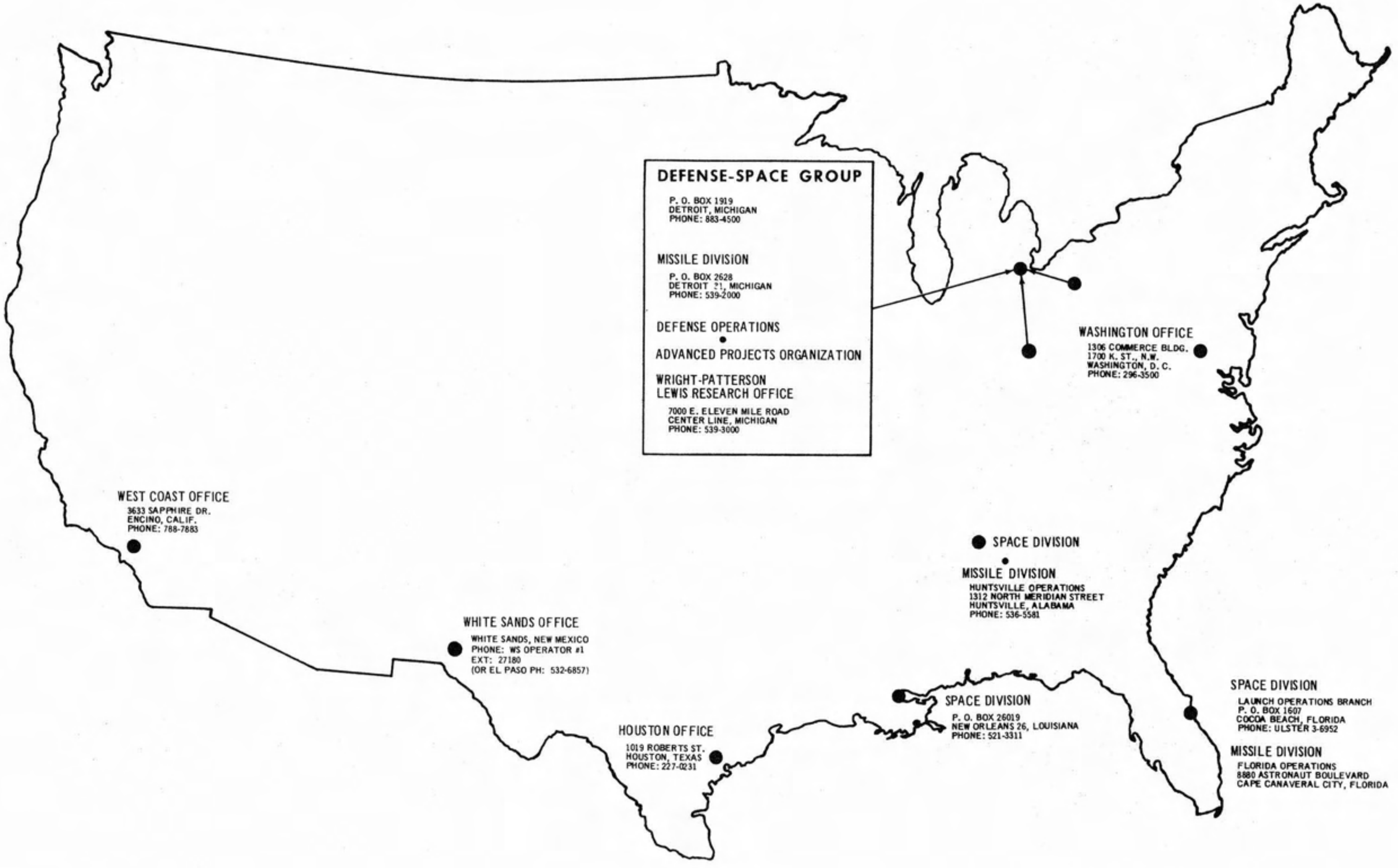

FIGURE 6. DEFENSE-SPACE GROUP OPERATIONS

A. MICHOUD OPERATIONS

In November 1961, the Chrysler Corporation Space Division was formed to negotiate a contract with NASA, a civilian organization engaged in the peaceful exploration of space, to build the booster stage of the Saturn I vehicle. In January 1962, 46 key staff personnel from both the Detroit and Huntsville Operations of the Missile Division moved into the Michoud plant to begin the operation of the Chrysler Corporation Space Division. Today there are more than 4,600 personnel in the division (approximately 3,150 at Michoud Operations and 1,500 at Huntsville Operations).

The Space Division (Fig. 7) is composed of 12 departments, each of which performs a vital function. The Michoud Operation while performing the administration for the Space Division provides the engineering and manufacturing support for producing the S-I/IB boosters, provides engineering support for the Huntsville Operations, and provides engineering and other support services for the Houston office.

The Program Control Office directs the development of appropriate work proposals and monitors and coordinates the activities of all departments to ensure that their efforts are proceeding according to the requirements of our contract.

The Engineering Department defines all system elements to be built, analyzes reliability of systems and total stages, proposes component redesign, conducts investigation into new space missions, and provides various support services.

The Systems Test Department, which static-fires the stage, provides launch and engineering support to the J. F. Kennedy Space Center, and supervises stage transportation between manufacturing location and test sites.

The Director of Operations coordinates the activities of four operating groups: Quality Control, Manufacturing, Materials, and Huntsville Operations.

The Quality Control Department tests and inspects product systems, components, and the completed vehicle, and establishes quality standards and inspection methods for the division and suppliers.

The Manufacturing Department fabricates parts and components and assembles the vehicle; develops the manufacturing processes for the fabrication and assembly of production items; provides cost estimating and

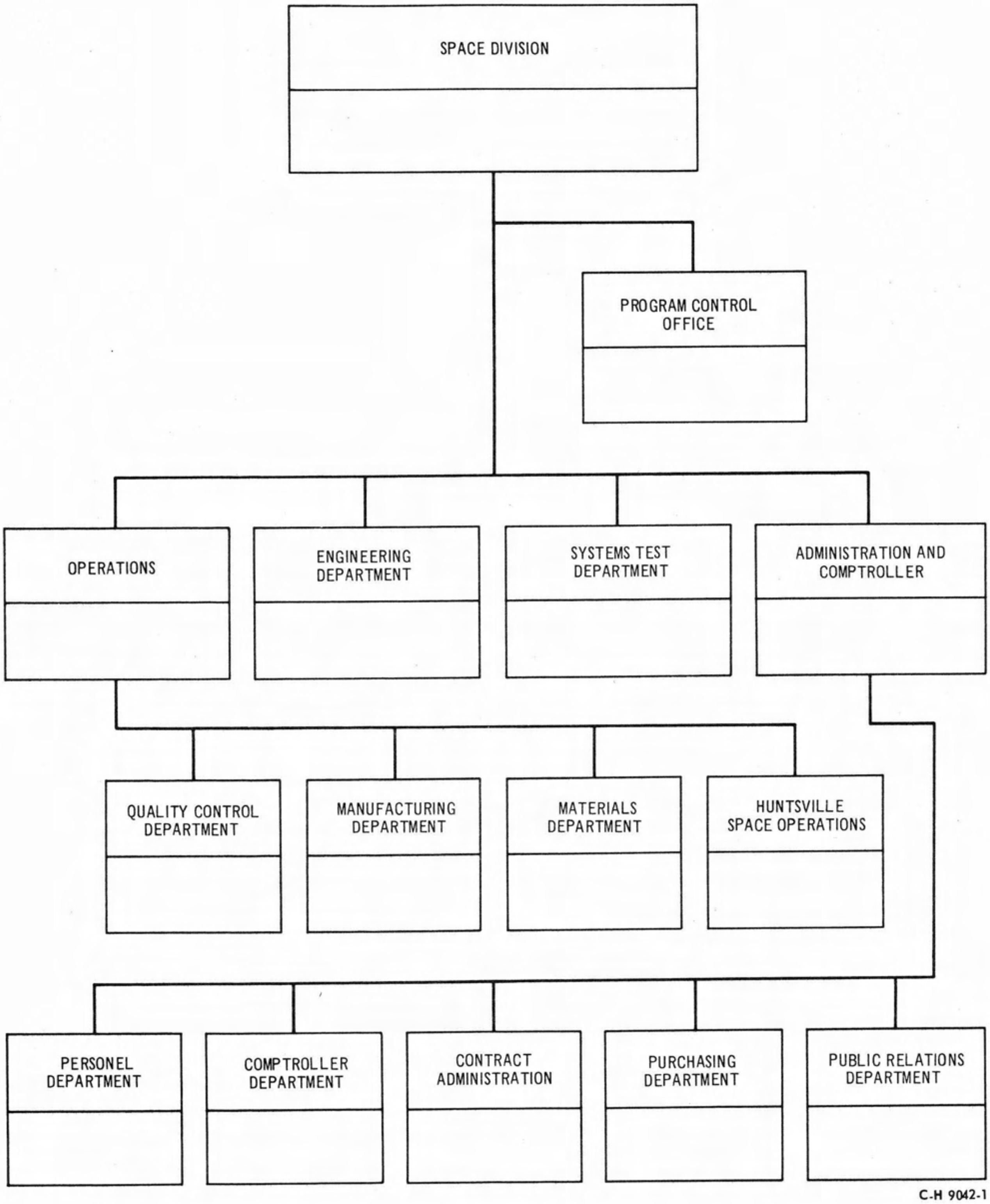

FIGURE 7. SPACE DIVISION ORGANIZATION

industrial engineering services; develops the plant layout; and designs, acquires, installs, and maintains plant equipment and facilities.

The Materials Department handles the receipt, movement, storage, preservation, and packaging of all production materials; identifies production material requirements; follows up their receipt and schedules them into production; and provides traffic service with commercial carriers.

Huntsville Operations conducts engineering, general and prototype manufacturing, and development operations in support of customer agencies and space and defense contractors.

The Vice President is in charge of the five administrative departments of the Space Division: Personnel, Comptroller, Contract Administration, Purchasing, and Public Relations.

The Personnel Department obtains and maintains a competent work force and provides for training, safety, employee relations, wage and salary administration, and the security of classified information.

The Comptroller Department is responsible for the direction of a financial control program, reviewing capital expenditure proposals, electronic processing of business data, systems and procedures activities, communications coordination, stationery storage and disbursement, and generation and maintenance of records and reports covering the accounting and treasury activities of the Space Division.

The Contract Administration Department negotiates and administers all prime contracts.

The Purchasing Department procures goods and services to provide facilities, equipment, production, and non-production materials and furnishes information concerning cost reduction programs, make-or-buy decisions, and new facilities programs.

The Public Relations Department develops and directs public, civic, and community relations.

B. HUNTSVILLE OPERATIONS

The Huntsville Operations of the Space Division (Fig. 8) continues to support the von Braun team at MSFC. Huntsville Operations also supports

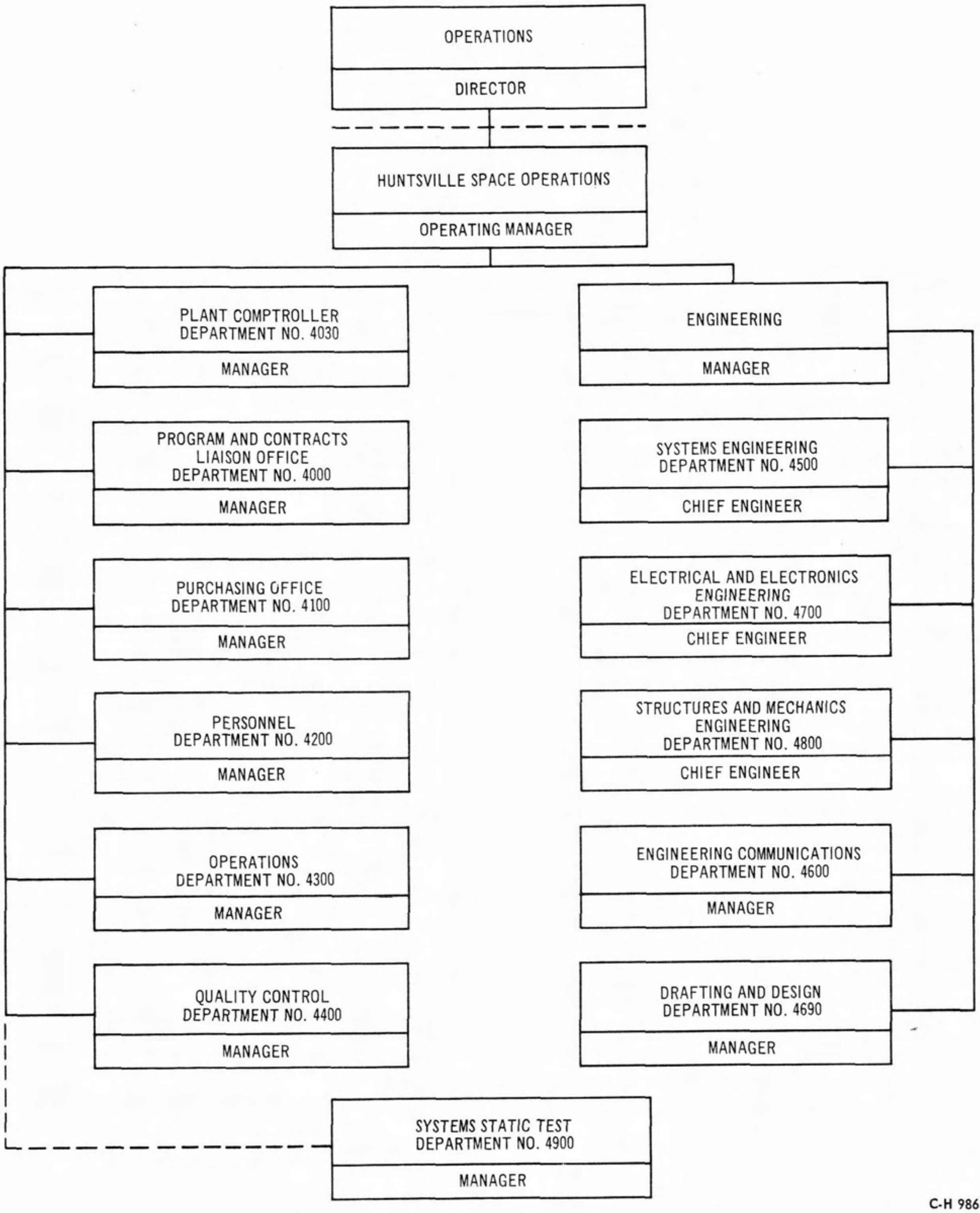

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FIGURE 8. HUNTSVILLE OPERATIONS ORGANIZATION

the Launch Support Equipment Engineering Division (located in Huntsville) of Kennedy Space Center.

The functions of the Huntsville operating departments are similar to those of the Michoud Operations.

The Plant Comptroller Department is responsible for the direction of a financial control program including generation and maintenance of records and reports covering the accounting and treasuring activities of the Huntsville Operation.

The Programs and Contracts Liaison office participates in securing new business and servicing current business. This office maintains control and program liaison with MSFC, the Army, Michoud, Kennedy Space Center, and with contractors.

The Purchasing Office procures goods, services facilities, equipment, and materials to carry on the support services provided by the Huntsville Operation.

The Personnel Department obtains and maintains a competent work force and provides for training, safety, employee relations, wage and salary administration, and the security of classified information.

The Operations Department maintains a manufacturing facility for the fabrication of prototype hardware and tooling, for custom mechanical and electrical construction, and for short production runs in support of MSFC laboratories. Also, the department furnishes the plant operating and engineering services for the Huntsville Plant.

The Quality Control Department maintains a quality control engineering, test, and checkout support activity in support of MSFC, including the establishment and execution of a Quality Control System in compliance with applicable contractual requirements. Also, the department maintains the quality control of all items manufactured by the plant, and establishes a system of surveillance on all plant measuring and test equipment requiring calibration and traceable to the Bureau of Standards.

The Systems Static Test Department is engaged in static testing of the booster. This department is a hybrid department in that personnel administration is provided by the Huntsville Operation and technical administration is provided by the Systems Test Department of the Michoud Operations. This department static-tests all stages built by Chrysler.

All the engineering departments of Chrysler Huntsville report to the Engineering Manager.

The Systems Engineering Department performs launch system design, development, and modification, including launch facilities, vehicle systems, ground equipment, instrumentation, and auxiliary equipment in support of both KSC and MSFC.

The Electrical and Electronics Engineering Department is engaged in the engineering design of guidance, control, and both airborne and ground instrumentation systems.

Ths Structures and Mechanics Engineering Department is engaged in the engineering and design of space vehicle structures and propulsion systems and evaluating the flight characteristics of space vehicles.

The Engineering Communications Department supports Chrysler aerospace and fabrication projects and MSFC laboratories in the preparation and reproduction of a variety of technical documents including manuals, handbooks, procedures, specifications, standards, purchase descriptions, reports, studies, brochures, charts, and special projects. The department also maintains a technical library and microfilm file.

The Drafting and Design Department provides design documentation of missile and space vehicle systems, components, and launch support equipment; establishes engineering documentation plans and programs, and coordinates drafting and design requirements with other engineering functions of Chrysler and customer agencies.

C. FLORIDA OPERATIONS

Chrysler Florida Operations, manned by both Missile Division and Space Division personnel, provides one of the most complete engineering and manufacturing facilities in the Cape Kennedy area in support of both NASA and the Air Force.

Engineering and technical personnel are actively engaged in launch complex design, facility equipment installation and modification, launch facility checkout, vehicle launch preparation, and facility refurbishing after launch for the Saturn I/IB, Atlas, Titan, Minuteman, and Centaur vehicles. The manufacturing facilities provide electrical/electronic and metal fabrication capabilities in support of the engineering services.

Increased S-IB mission contract responsibilities have further broadened the scope of work performed and the number of people engaged at Florida Operations. With this increased responsibility, a reorganization of the Florida Operations has been initiated to include sections for Personnel, Administration, Mechanical Engineering, Instrumentation Engineering, Electrical and RF Engineering, Logistics Engineering, Launch Support Equipment Engineering, Quality Engineering, Testing Engineering and Operations Engineering. An organizational chart with well defined section functional responsibility has not been established at the time of this printing.

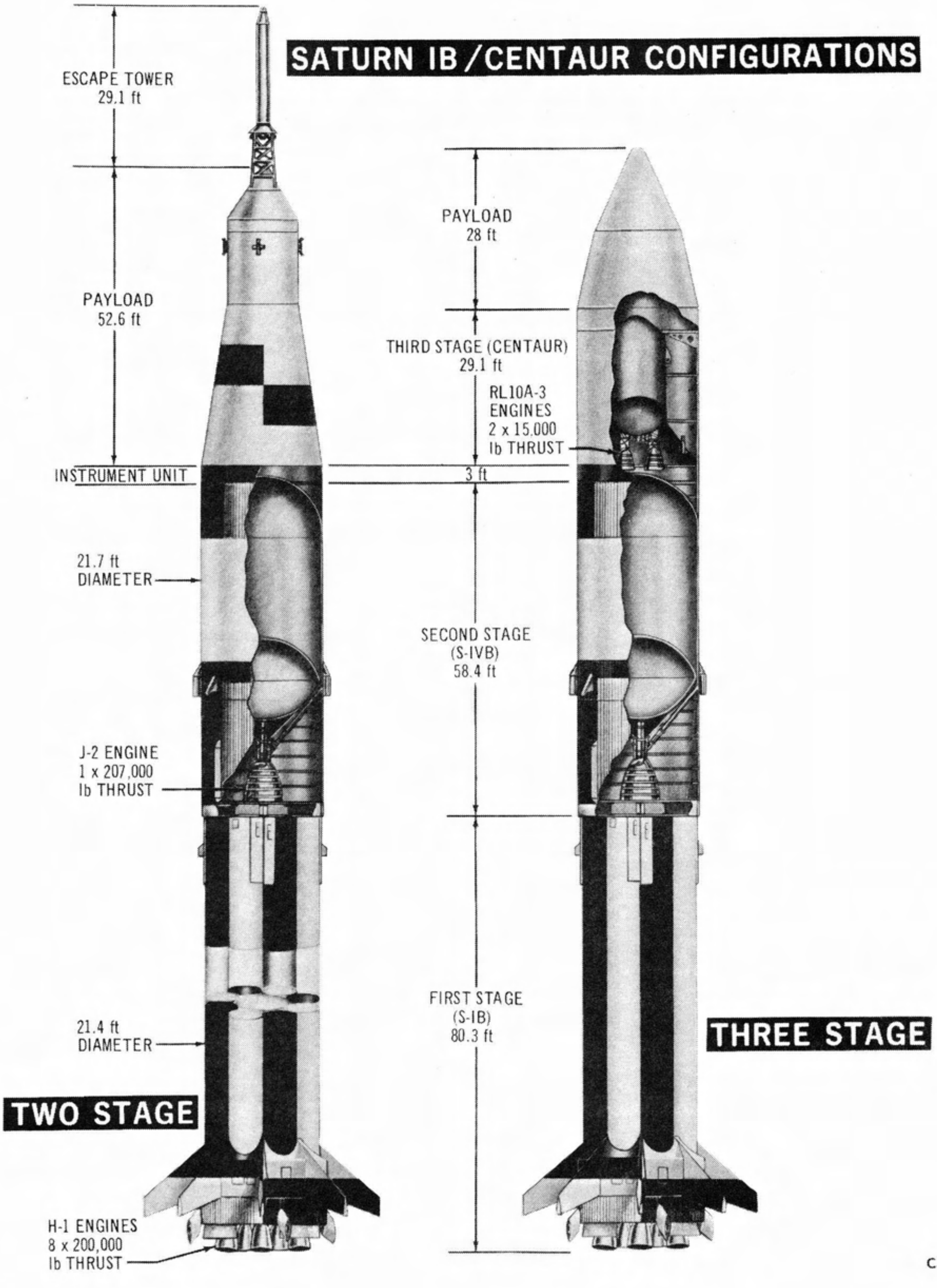


FIGURE 9. SATURN IB CONFIGURATIONS

SECTION III. SATURN IB VEHICLE DESCRIPTION

A. GENERAL DESCRIPTION

Figure 9 shows the major characteristics of Saturn IB, the second-generation successor to Saturn I, and by far the most powerful in its payload class being manufactured today. The Saturn IB two-stage vehicle is capable of injecting a basic payload of approximately 37,000 pounds into a 100-nautical-mile orbit. With a Centaur third stage, it is capable of delivering an earth-escape payload of approximately 12,000 pounds, or a Voyager payload of approximately 9,000 pounds, to the Planet Mars. The two-stage vehicle is approximately 191 feet long (including the launch escape system), approximately 21 feet at the largest diameter, and weighs approximately 1,262,400 pounds at liftoff. Eight tail fins on the S-IB stage provide support and hold-down points for launch and, under certain conditions, aerodynamic stability during flight.

Eight liquid-fueled Rocketdyne H-1 engines, each developing 200,000 pounds of thrust, power the S-IB stage. The four outboard engines are gimbal mounted for directional control. A single 200,000-pound thrust LH_2/LOX Rocketdyne J-2 engine powers the S-IVB stage. The engine is gimbal mounted to provide pitch and yaw control.

The S-IVB stage attaches to the S-IB stage through the S-IVB aft interstage. The aft interstage is bolted to the spider beam of the S-IB stage, and S-IB/S-IVB separation occurs between the S-IVB aft skirt and the S-IVB aft interstage.

A 260-inch-diameter, 36-inch-high, unpressurized, instrument unit is located between, and attached to, the S-IVB forward skirt and the payload adapter assembly. The instrument unit houses the vehicle control system, guidance and control system, tracking systems, and power supplies.

A payload assembly, consisting of the Apollo spacecraft with the launch escape system attached, mates to the instrument unit through the payload adapter assembly. The Apollo spacecraft consists of a command module, a service module, and a lunar excursion module. These modules are arranged so that three astronauts can make a lunar orbital rendezvous approach to the moon, explore its surface, and return to earth. One of the Saturn IB's missions is to train astronauts in this technique.

A Saturn IB three-stage configuration uses the flight-proven Centaur as a third stage. Two restartable LH_2/LOX fueled Pratt and Whitney RL-10A-3 engines power the Centaur. Other configurations under study for improving the capabilities of the Saturn IB booster include using proven solid or liquid strap-on units, the mixing of fluorine with LOX called FLOX, and elongating the S-IB propellant containers. These advanced S-IB stage configurations could increase the payload capacity of the entire vehicle by approximately 40 percent.

The black and white painting pattern of the Saturn IB vehicle aids ground tracking stations in establishing orientation of the vehicle during its initial stage of flight. Because of heat transfer considerations, the fuel containers of the S-IB stage are painted predominantly black and the LOX containers are painted white. The launch escape tower is painted red, and a red "UNITED STATES" on a white background is painted on the S-IB stage fuel containers. The painting adds approximately 1,000 pounds of weight to the vehicle.

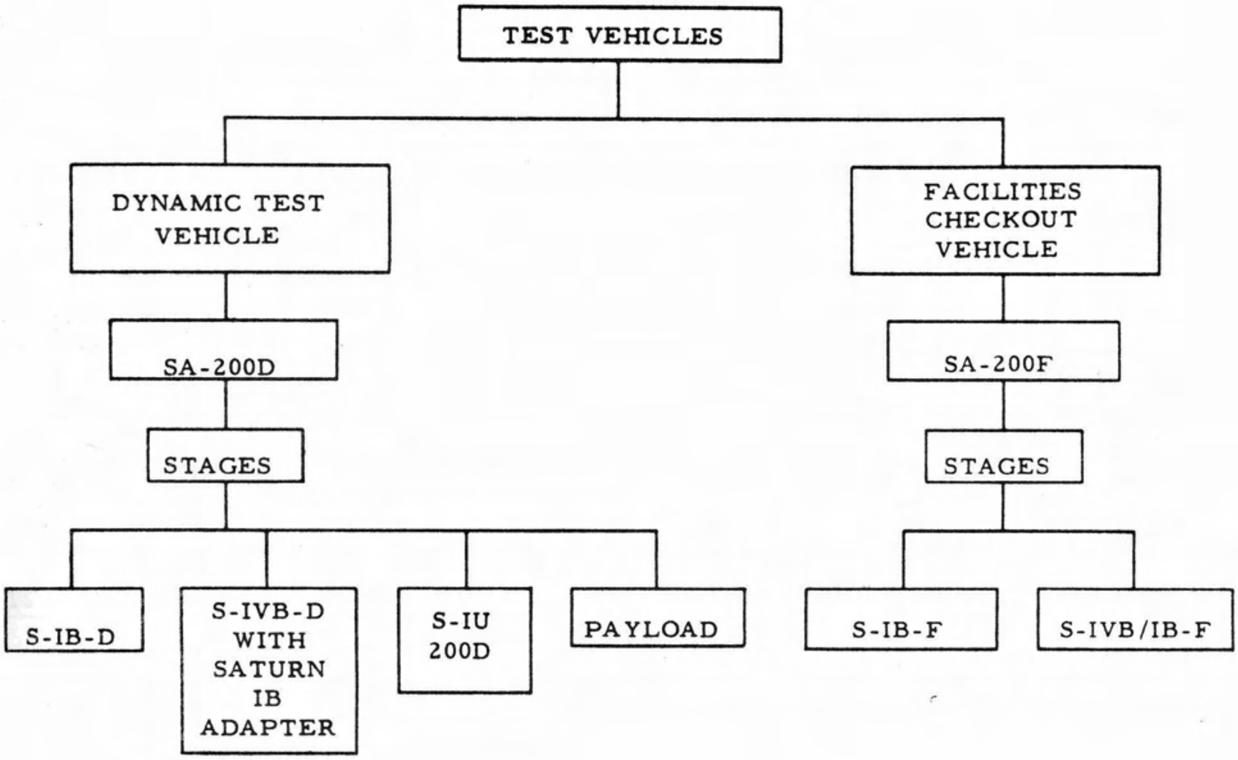
B. VEHICLES NOMENCLATURE

The following information is for orientation and familiarization with various Saturn IB vehicles and stage elements that will be produced. The dynamic test vehicle, the facilities checkout test vehicle, and the test stages associated with each are indicated, together with a series of special test stages. The three categories of flight vehicles (prototype, qualification, and production) are identified, and the stage elements and instrument units are designated by name and number. Tables 2 and 3 show a complete breakdown on the vehicles and stage elements.

1. Dynamic Test Vehicle (SA200D). The dynamic test vehicle will duplicate the structures, mass characteristics, and essential systems incorporated in the Saturn IB flight configuration. The vehicle, placed in the dynamic test tower, will be used to verify vehicle bending modes and frequencies under simulated "on pad" and flight conditions. The great majority of engineering changes will result from findings determined from tests conducted on this vehicle.

2. Facilities Checkout Test Vehicle (SA200F). The facilities checkout test vehicle will consist of the S-IB-F stage and the S-IU-200 V/500 V elements. The facilities checkout will verify operational status of complex 34 and its compatibility with the flight vehicle. This will include handling and erection of the Saturn IB, service structure adjustment for enclosing and providing access to the vehicle, verification of all launch support equipment connections, operation of the pneumatic systems, operation of the propellant transfer and loading systems, and checkout of the environmental control system.

TABLE 2. GROUND TEST VEHICLE NOMENCLATURE



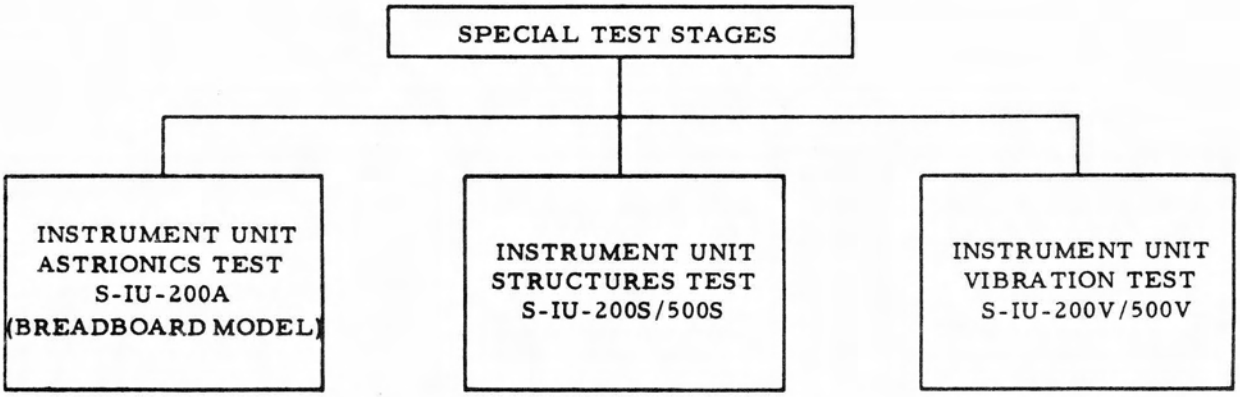
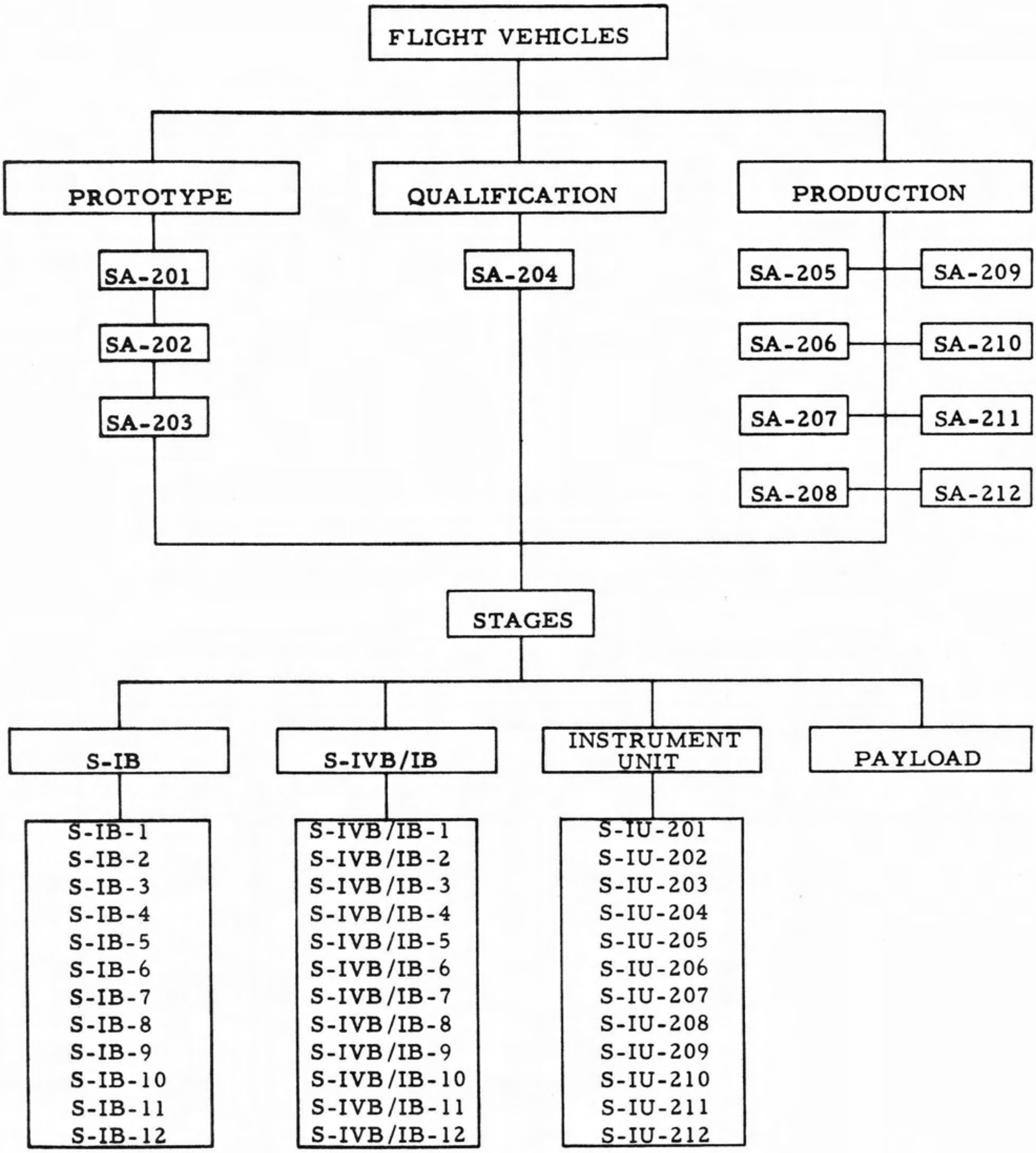


TABLE 3. FLIGHT VEHICLES NOMENCLATURE



3. Captive Firings. Each stage (S-IB and S-IVB) of each vehicle will be static tested prior to use in a flight vehicle.

4. Flight Vehicles. Table 3 presents the various stage combinations comprising a given flight vehicle.

C. UNIT NUMBERING AND COMPONENT DESIGNATION

The vehicle is divided in units for quickly determining the physical location of electrical and mechanical components.

The unit numbering method for electrical and mechanical reference designations (finding numbers) is adapted from MIL-STD-16. Figure 10 identifies the basic vehicle units. Unit locations are as follows:

Units 1 through 8 - The four inboard and four outboard engines and their immediate area below the firewall.

Unit 9 - The thrust frame area and area below propellant container bulkheads, including the lower skirts of propellant tanks.

Unit 10 - Propellant container area, upper bulkhead to lower bulkhead.

Unit 11 - The spider beam area and area above propellant container bulkheads. Also, the antenna panels are included in Unit 11.

Unit 12 - The instrument compartment located in the top skirt of fuel container number 2.

Unit 13 - The instrument compartment located in the top skirt of fuel container number 1.

Units 14 and 15 - deleted.

Units 16 through 23 - Eight tail fins.

Electrical components installed in a given unit are designated as subassemblies of that unit and are identified by means of a coded number/letter combination.

A typical component designation code will contain the following: (1) the basic reference unit (by number), (2) the subassembly (by letter), (3) the

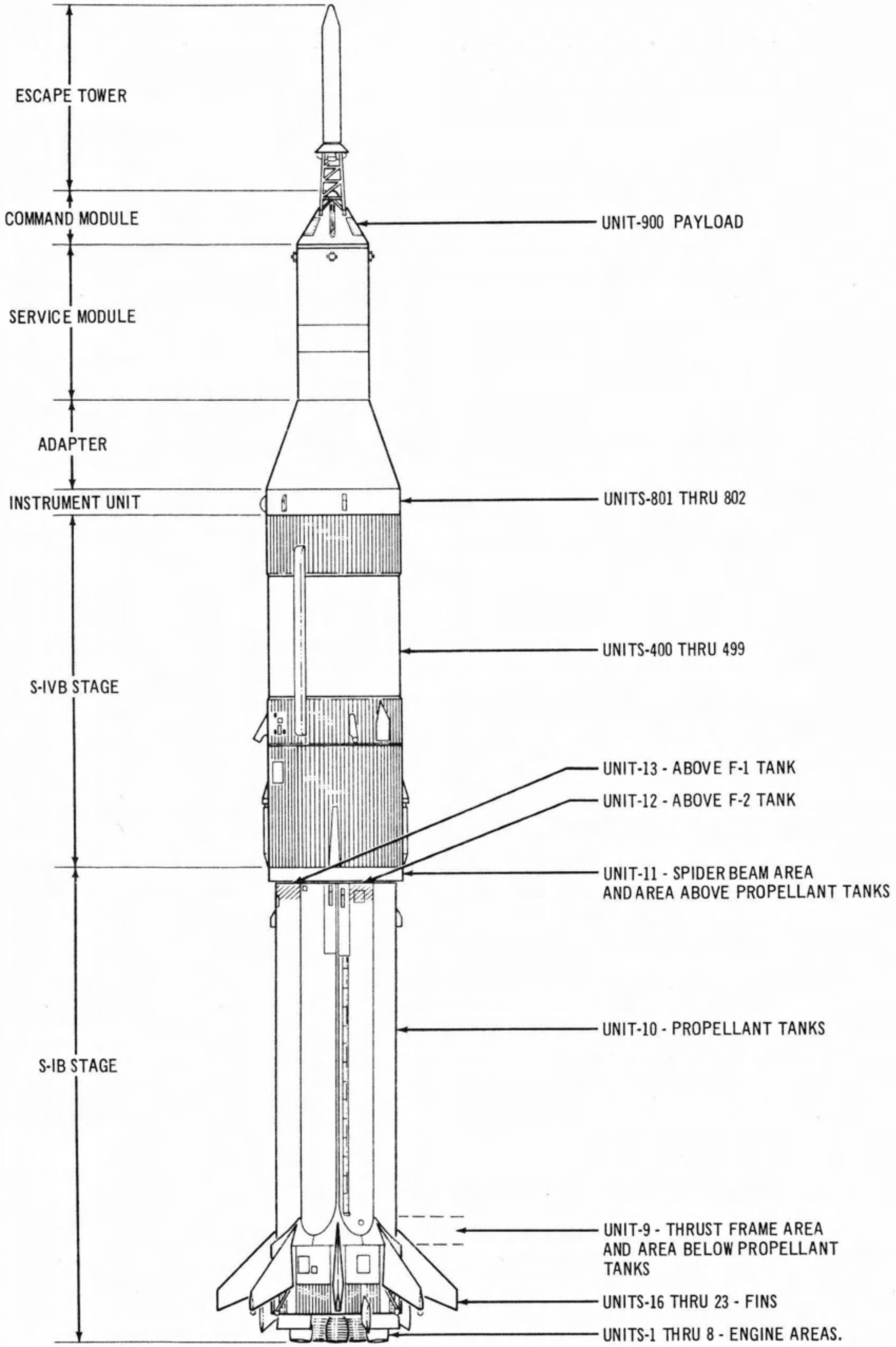


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FIGURE 10. SATURN IB STAGE AND UNIT DESIGNATIONS

number assigned to the subassembly (by number), (4) the name of the component (by letter), and (5) the number assigned to the component which differentiates that component from identical units in this or other subassemblies.

EXAMPLE 1: Relay

12 A 1 K 1

1 — Specifies that this is the No. 1 relay.

K — Indicates that the component is a relay.

1 — Indicates this is the first "A" subassembly.

A — Indentifies subassembly "A" of the instrument compartment.

12 — Locates the relay in unit 12, an instrument compartment.

EXAMPLE 2: Terminal E207 of Main Distributor

12 A 1 E 207

207 — Terminal number.

E — Indicates an electrical terminal.

1 — Locates the terminal in the first "A" subassembly.

A — Indicates terminal is in an "A" subassembly.

12 — Locates the terminal in unit 12.

D. S-IB STAGE

The S-IB stage (Fig. 11), manufactured by Chrysler Corporation at Michoud, is approximately 80 feet long, 21 feet in diameter, and has a fin span of approximately 40 feet. A stage systems simplification and weight reduction effort, combined with more powerful engines, allows larger payloads to be launched by this stage than originally planned. Compared to the S-I stage, significant weight reduction has been achieved in the S-IB stage through design modification, deletion of components, and elimination of complete systems. The major changes include:

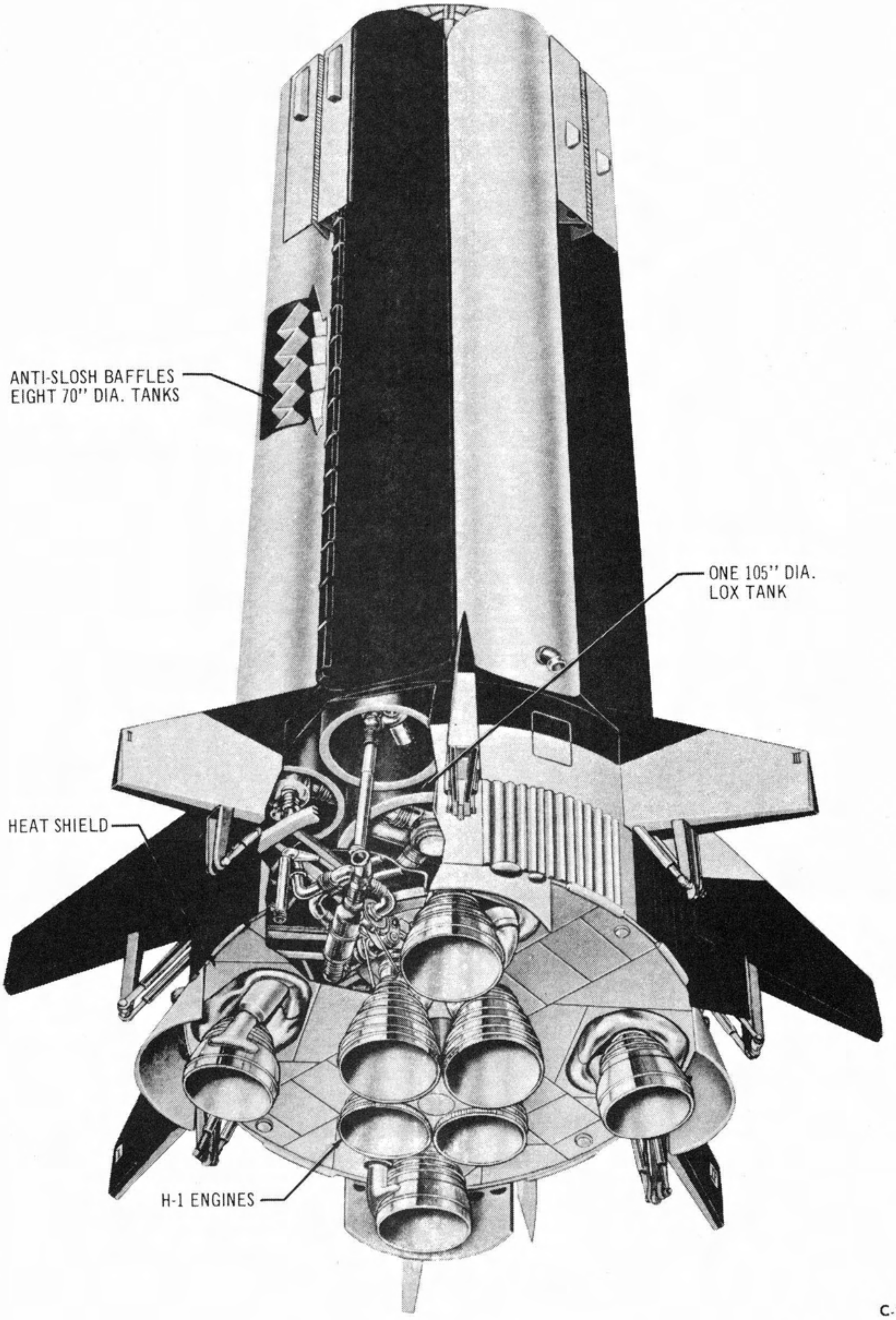

FIGURE 11. S-IB STAGE

Elimination of the LOX-SOX disposal system.

Elimination of LH_2 vent and exhaust system.

Elimination of movie and TV camera systems.

Sixty percent reduction in instrumentation measurements and attendant equipment.

Four large and four stub tail fins replaced with eight swept-design identical fins.

Tail section assembly modified to reduce weight.

Propellant container skirt skin thickness reduced.

Spider beam shortened, and beams and splice plates reduced in thickness.

Retromotors relocated from S-IB stage to S-IB/S-IVB interstage.

Elimination of GOX check valves.

Substitution of a computer-controlled switch selector flight control system for the flight sequencer system previously used.

Other changes effective on the S-IB stage are a reduction in electrical components and the use of helium instead of GN_2 for fuel tank pressurization. Additional data on the S-IB stage are presented in table 4.

The base of the S-IB stage is the tail section thrust structure assembly. The eight engines attach to the thrust structure aft of the firewall. The engines are partially enclosed by the tail shrouds and heat shield, and only the engine thrust chambers and heat exchangers are visible. Engine thrust is transmitted from the thrust structure through the LOX containers to the spider beam unit assembly.

The container section consists of a 105-inch-diameter center LOX container, four 70-inch-diameter LOX containers, and four 70-inch-diameter fuel containers. The eight 70-inch containers are clustered around the 105-inch container. The combined LOX capacity of the 105-inch LOX container and the four 70-inch LOX containers is approximately 622, 000 pounds. The combined fuel capacity provided by the four 70-inch fuel containers is approximately 260, 000 pounds. The fuel containers are mounted to the spider beam unit assembly with floating attachments to allow for LOX container

TABLE 4. S-IB STAGE STATISTICAL DATA

Gross Weight at Liftoff	971,700 lbs.
Propellant Weight	882,400 lbs.
Engines (8)	H-1 Rocketdyne
Thrust per Engine	200,000 lbs.
Total Thrust (Sea Level)	1.6 million lbs.
Valves and Control Devices	310
Measurements during Flight	300
Electrical and Electronic Components	1,708
Electrical Network Connections (Excluding Internal) of Above Components	73,000
Wiring Used	53 miles
Structural Fabrication	27 weeks
Final Assembly	17 weeks
Note: All figures are approximate.	

shrinkage when the booster is loaded with liquid oxygen. Two 20-cubic-foot capacity, high-pressure helium (He) spheres are mounted in the forward sections of fuel containers F-3 and F-4. Instrument compartments are located in the forward sections of fuel containers F-1 and F-2.

The spider beam forms the forward structure of the stage and serves to anchor the forward end of the propellant containers. Seal plates cover the forward side of the spider beam.

1. Tail Area. Installation of the water quench and barrel heater system, engine purge system, LOX and fuel wraparound suction lines, lower LOX replenishing line, and fire detection system transform the structural tail section assembly into the tail unit assembly. To utilize optimum accessibility, these installations (Fig. 12) are normally performed before the clustering operation.

The boattail conditioning and water quench systems are perforated pipes routed from a quick disconnect coupling at the heat shield up the shroud and along the thrust outriggers at fins I, II, III, and IV to the center barrel. This is a threefold system: first, it provides the necessary water quench capability for firings; second, it provides a means to purge the tail area by ground source; and third, it provides the necessary ducting for ground heating of the tail area.

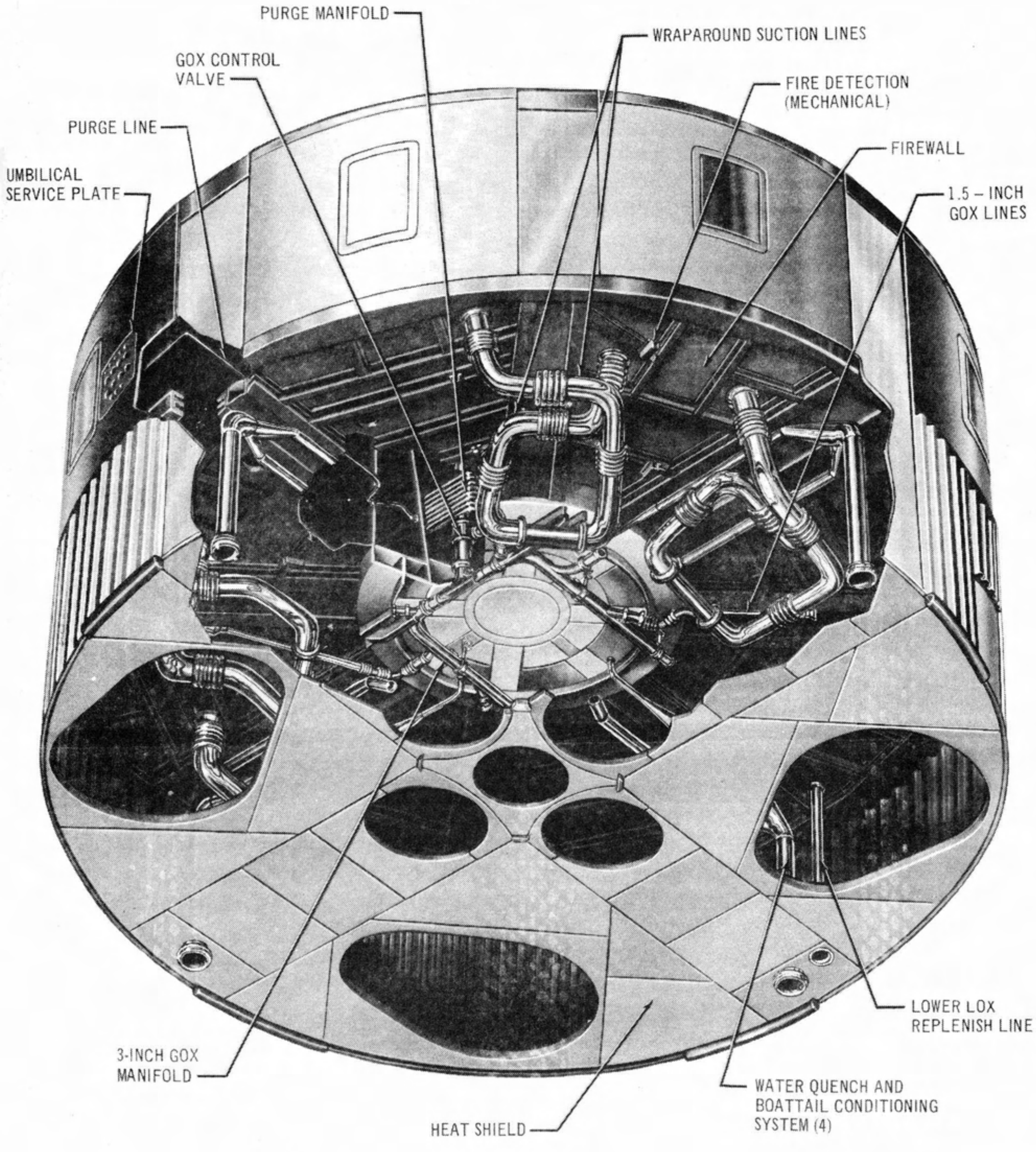

FIGURE 12. TAIL UNIT ASSEMBLY

The engine purge system provides for the routing of engine purge lines from the two umbilical service plates on the shroud to the purge manifold in the center barrel assembly. Lines extend from the manifold through the firewall to each of the engines. Each engine purge system consists of: LOX pump seal purge and gearbox pressurization, LOX dome purge, gas generator LOX injector manifold purge, and thrust chamber fuel injector manifold purge. The LOX pump seal purge and gearbox pressurization obtains GN_2 from the control pressure spheres. The remaining purge systems obtain GN_2 from the ground control source.

The 1.5-inch-diameter GOX lines from the GOX manifold to the outboard engines are prefitted for installation after the engines are installed. The mechanical components of the fire detection system are installed, and the inflight heat shield panels and star assembly are prefitted. Test configuration panels are used for static test. The inflight panels are reinstalled during poststatic and preparation for shipment operations.

The component installations in the aft skirts of all the LOX container unit assemblies are almost the same for each container (Fig. 13). Two suction line ball rotor LOX shutoff valves (prevalves) are installed along with the actuating pressure tubing and various tubing assemblies used for pressure pickup, control, etc. The LOX fill and drain valve is installed on the sump of container L-3.

The aft skirt of fuel container F-3 contains the control pressure GN_2 storage sphere with the associated regulators, control valves, and connecting tubing. The control pressure system supplies GN_2 pressure to operate the electrically controlled pressure-operated fuel vent valves, LOX vent valves, the LOX and fuel prevalves, and the LOX and fuel fill and drain valves. The fuel fill and drain valve is located in the aft skirt of fuel container F-1. The system supplies pressure for pressurizing the turbopump gearboxes, purging the LOX seals, and purging the calorimeters.

Measurement racks and distributors are located in the aft skirts of the fuel containers. Some of the measuring racks and electrical distributors are shown in figure 13. For additional information refer to the Saturn IB Flight Measurements Manual.

Figure 13 shows the LOX and fuel interconnect lines and suction lines. Each outer container supplies one inboard and one outboard engine. The LOX containers are interconnected through the sump of the 105-inch LOX container unit. The LOX replenishing system is routed from the heat shield to the sump of LOX container L-4.

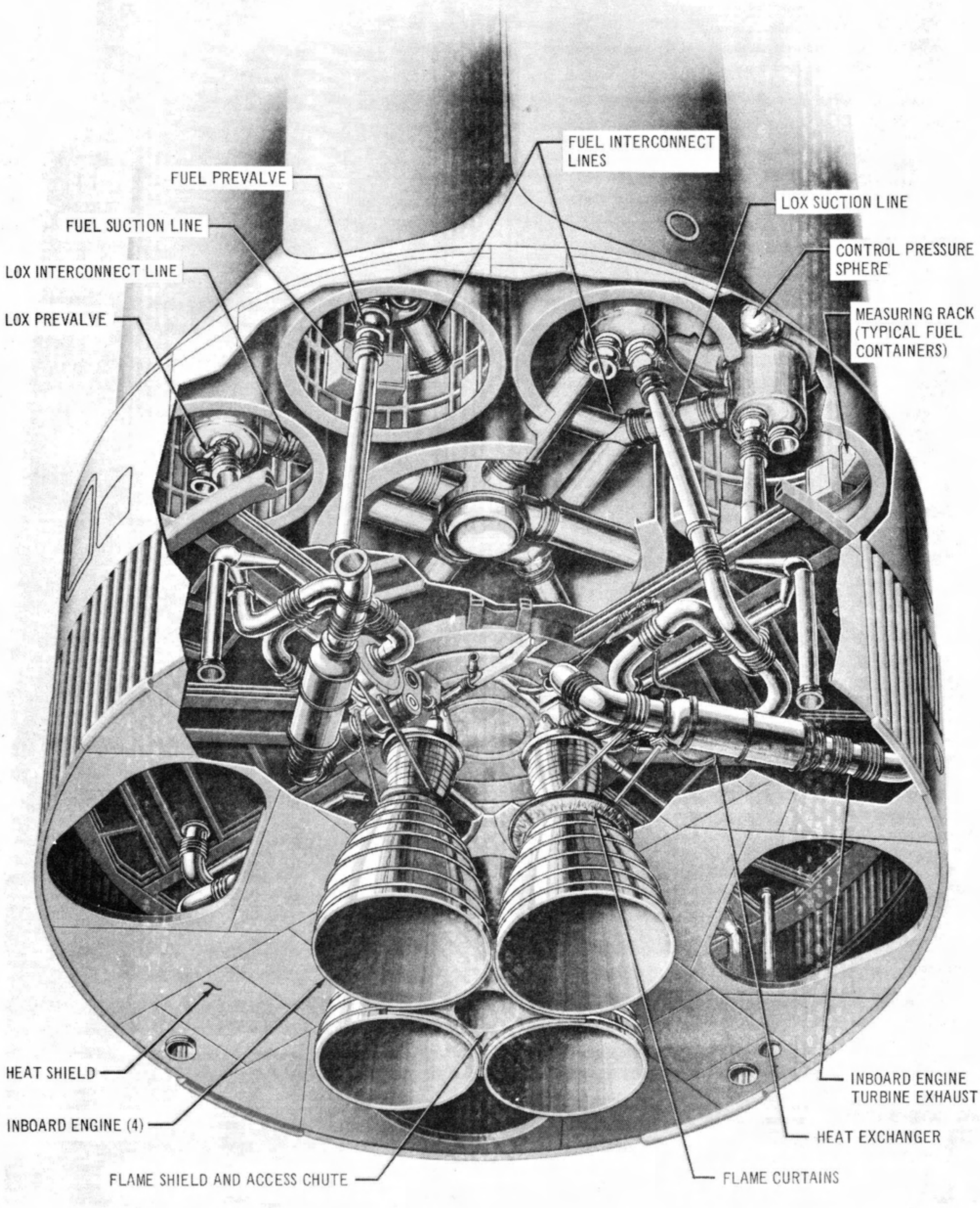

FIGURE 13. TAIL AREA, OUTBOARD ENGINES REMOVED

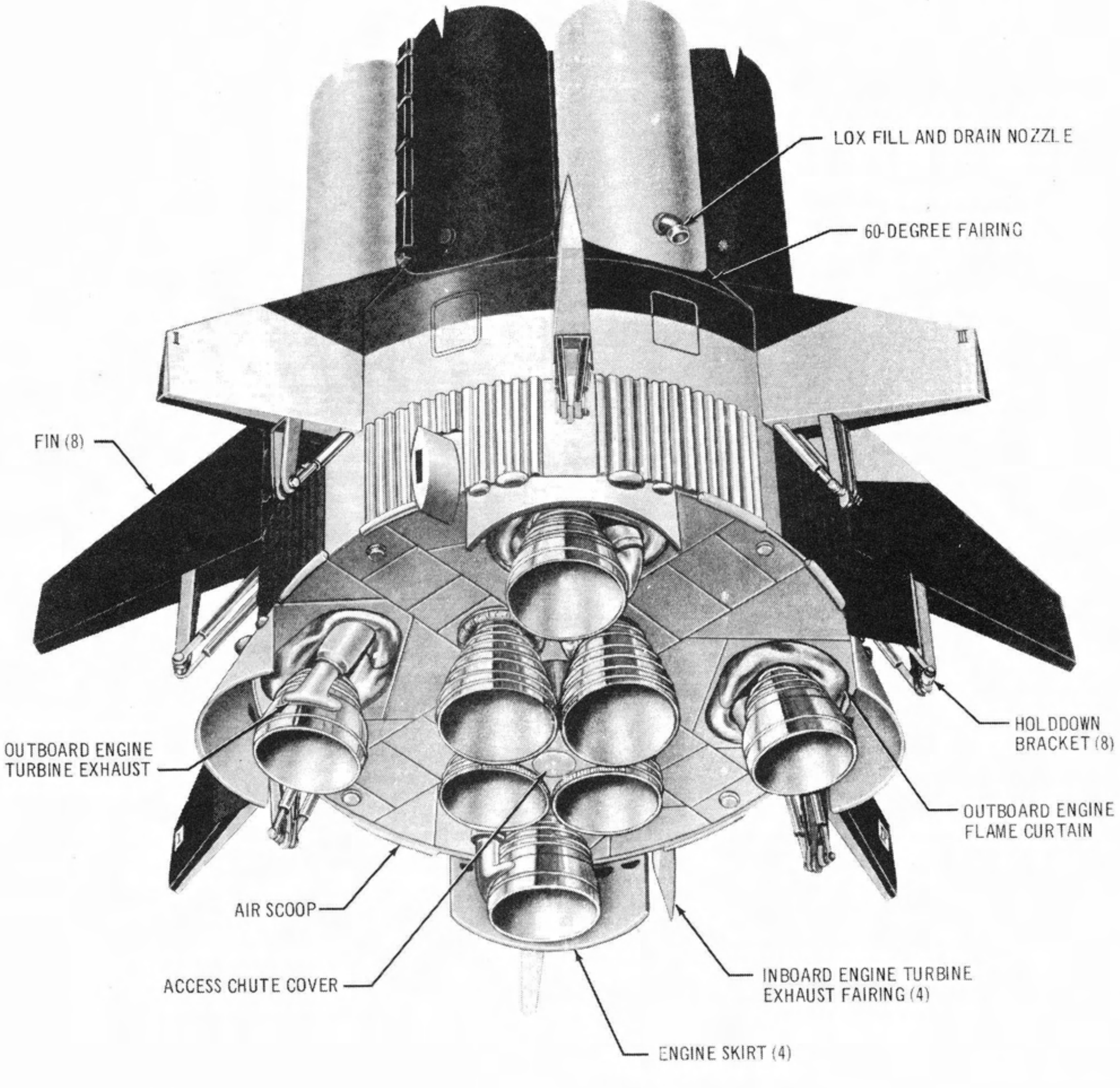

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FIGURE 14. TAIL AREA, COMPLETE

The four inboard engines are rigidly mounted to the thrust structure assembly in a square pattern around the centerline of the vehicle. The engines are canted outward at a three-degree angle. A flame shield and access chute forms a heat barrier between each of the inboard engines. Additional engine compartment temperature control is provided by the heat shield and the flexible flame curtains. The inboard engine gas generators are exhausted through the inboard turbine exhaust system and heat exchanger. GOX for pressurizing the LOX tanks is obtained by routing LOX through the heat exchanger and converting it to gaseous oxygen. The gaseous oxygen is routed through a 3-inch GOX manifold to a GOX flow-control valve and then through the center LOX tank to the LOX pressurization manifold (GOX distribution system).

The outboard engines (Fig. 14) are gimbal mounted to provide a movement of plus or minus 8 degrees by any one actuator. Engine gimbaling is accomplished through two actuators operating in a closed hydraulic system. Gimbaling action is initiated by electrical signal from the guidance system through an electro-hydraulic servo valve on each actuator.

Flexible purge and propellant bubbling lines to the engine from the firewall permit engine gimbaling. The final length of the 1.5-inch GOX line to the outboard engine is flexible. The turbine exhaust system is a component part of the outboard engine, and aspirates through a port on the periphery of the engine nozzle. This type of setup for the exhaust system conserves space and permits engine gimbaling. The flexible flame curtains around the engines, while preventing excessive engine compartment temperatures, allow freedom of movement for the engines.

Eight swept fins, four inboard engine turbine exhaust fairings, eight airscoop skins, and four engine skirts are installed on the tail of the S-IB stage. The turbine exhaust fairings aspirate the exhaust gases from the inboard engines. The airscoops and engine skirts direct the flow of air around the tail section to control tail heating and aerodynamic loading on the engines.

At the forward end of the tail unit, 60-degree fairing assemblies provide an aerodynamic seal between the propellant container assembly and the tail unit assembly.

2. Propellant Containers. The container area (Fig. 15) encompasses the four fuel tanks, the five LOX tanks, and pertinent auxiliary components. There are more similarities than differences between the individual containers. For a summation of similar and different characteristics, refer to table 5 and figure 15.

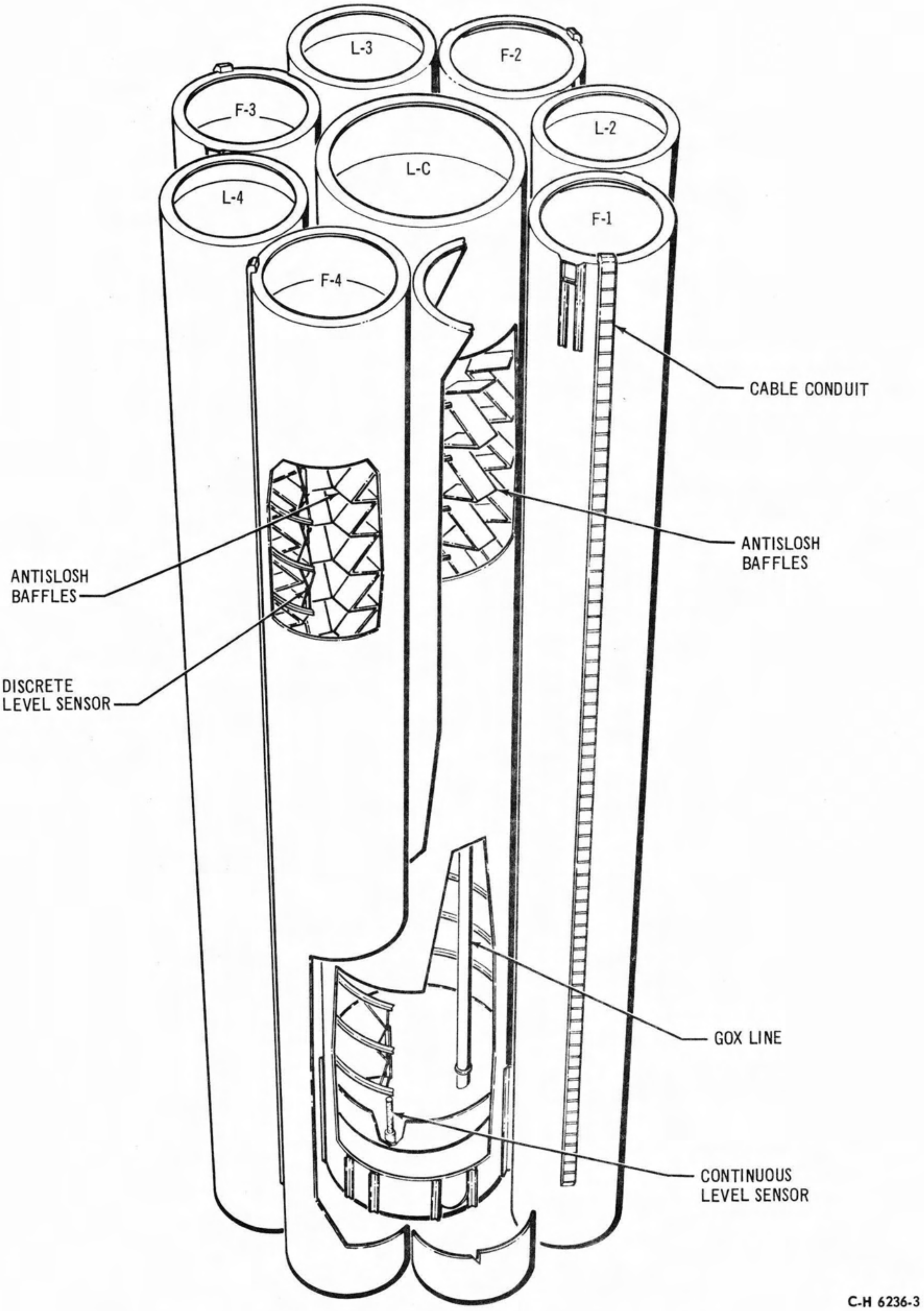

FIGURE 15. PROPELLANT CONTAINERS

TABLE 5. MAJOR SIMILARITIES AND DIFFERENCES OF CONTAINERS

Component	Purpose and Use	Container
Anti-Slosh Baffles	To help maintain stable load	All LOX All fuel
Continuous and Discrete Liquid Level Sensor Systems	To indicate coarse and fine liquid quantity	All LOX All fuel
GOX Line	To directly pressurize 105" container, and manifold pressurize the 70" containers	LOX, 105"
LOX and Fuel Level Sensor System	To arm separation and retro-rocket EBW firing units. To give time base change command to IU	LOX, L-2 and L-4, fuel, F-2 and F-4
Fuel Depletion Sensors	To initiate outboard engine cutoff	F-2 and F-4
Sumps	To improve propellant transfer characteristics	All fuel All LOX
20-Cubic-Foot High-Pressure He Spheres	To supply helium for fuel tank pressurizing	Fuel, F-3 and F-4
Electrical Cable Installations	Route cables from aft skirts to instrumentation assemblies	All fuel
Instrumentation Compartment	Houses instrumentation, telemetry and electrical components	Fuel, F-1 and F-2

a. The center LOX container unit assembly internal arrangement 60C10130 is 105 inches in diameter and 749.679 inches long. In addition to the components listed in table 5, the center tank has a sump and fuel interconnect manifold located in the aft skirt.

After the auxiliary components (including connecting hardware, tubing, and wiring) are installed in the forward and aft skirts and on the skin, the center LOX container unit assembly becomes the 105-inch-diameter LOX container, unit assembly 60C10014.

b. The 70-inch LOX containers are 747.43 inches long and 70 inches in diameter. After installation of the auxiliary components, each container weighs approximately 3700 to 4100 pounds.

After components are installed on the external skin and in the skirts, the containers become 70-inch LOX container unit assemblies. Table 6 is a quick reference to this transformation.

TABLE 6. CONTAINER IDENTIFICATION

Container Number	Container Unit Assembly (Internal Arrangement)	Container Unit Assembly (After Component Installation)
LOX	Drawing No.	Drawing No.
L-105	60C10130	60C10014
L-1	60C10131	60C10005
L-2	60C10132	60C10006
L-3	60C10133	60C10007
L-4	60C10134	60C10008
Fuel		
F-1	60C10135	60C10009
F-2	60C10136	60C10010
F-3	60C10137	60C10011
F-4	60C10138	60C10012

c. The 70-inch-diameter fuel container unit assemblies are 743.804 inches long. Table 6 identifies the containers, the internal arrangement drawings, and the containers after component installation. The internal arrangement of the fuel containers is similar for all containers (Fig. 15); however, there are some differences. See table 5. The most obvious difference between the fuel containers is the forward bulkheads of containers F-1 and F-2 that form instrumentation compartments, units 13 and 12 respectively. Feed-through adapters for the fuel pressurization system are also installed on the forward bulkheads.

The electrical cables for valve control, measurements, guidance control, and other instrumentation are routed along the external skins of the fuel containers and covered with conduit covers. For detailed information on all containers, refer to the drawings listed in table 6.

3. Spider Beam Area. The spider beam unit assembly (Fig. 16), while structurally supporting the S-IB stage forward end, adapts the S-IB stage to the S-IVB aft interstage and transmits thrust to the S-IVB stage. The assembly also provides mounting for various measuring components and control and measuring tubing. Seal plates installed on the forward side of the spider beam protect the S-IB stage from the blast of the S-IVB engine during S-IVB stage ignition. These plates also form the aft seal of the S-IVB aft interstage area, and provide a compartment between the stages, which can be environmentally controlled.

The LOX pressurizing and vent system (Fig. 16) is interconnected through the pressurization manifold in the forward end of the center LOX container. Prelaunch pressurization is accomplished by using helium from a ground source. Inflight pressurization is maintained by GOX obtained by passing LOX through the heat exchangers in the entire turbine exhaust systems. The GOX flows into a common manifold, through a flow regulator valve, and into the center LOX container. The remaining LOX containers receive GOX from the upper interconnect lines (GOX distribution system) associated with the center LOX container. GOX pressure is bled off by one 7-inch and two 4-inch vent lines to the outside during prelaunch operations.

The fuel pressurization manifold interconnects the fuel containers at the forward ends. Inflight pressurizing helium is supplied by the two 20-cubic-foot spheres located in the forward skirts of containers F-3 and F-4. Two fuel vent valves located in the pressurization manifold, in containers F-3 and F-4, mechanically maintain proper pressure.

The S-IB stage power supply, recording equipment, telemetry equipment, flight sequencing equipment, signal transmitting and receiving equipment, measuring equipment, vehicle control, and other instrumentation and electrical equipment are mounted in instrumentation compartments, units 12 and 13 located in the forward skirts of fuel containers F-2 and F-1 respectively. The instrumentation and electrical assemblies are first prefitted in an assembly fixture before they are installed in the vehicle. For more detailed information, refer to drawings 60C10023 and 60C10024, and Saturn IB Vehicle Data Books and the Saturn IB Instrumentation Systems Descriptions. The instrumentation compartments are cooled and then purged during countdown through a cooling system that obtains conditioned air and GN_2 (for purging) from the environmental conditioning system of the launch support equipment. Instrumentation, command, and telemetry antennas are installed on panels located at the forward end of the stage along fin lines I, II, III, and IV.

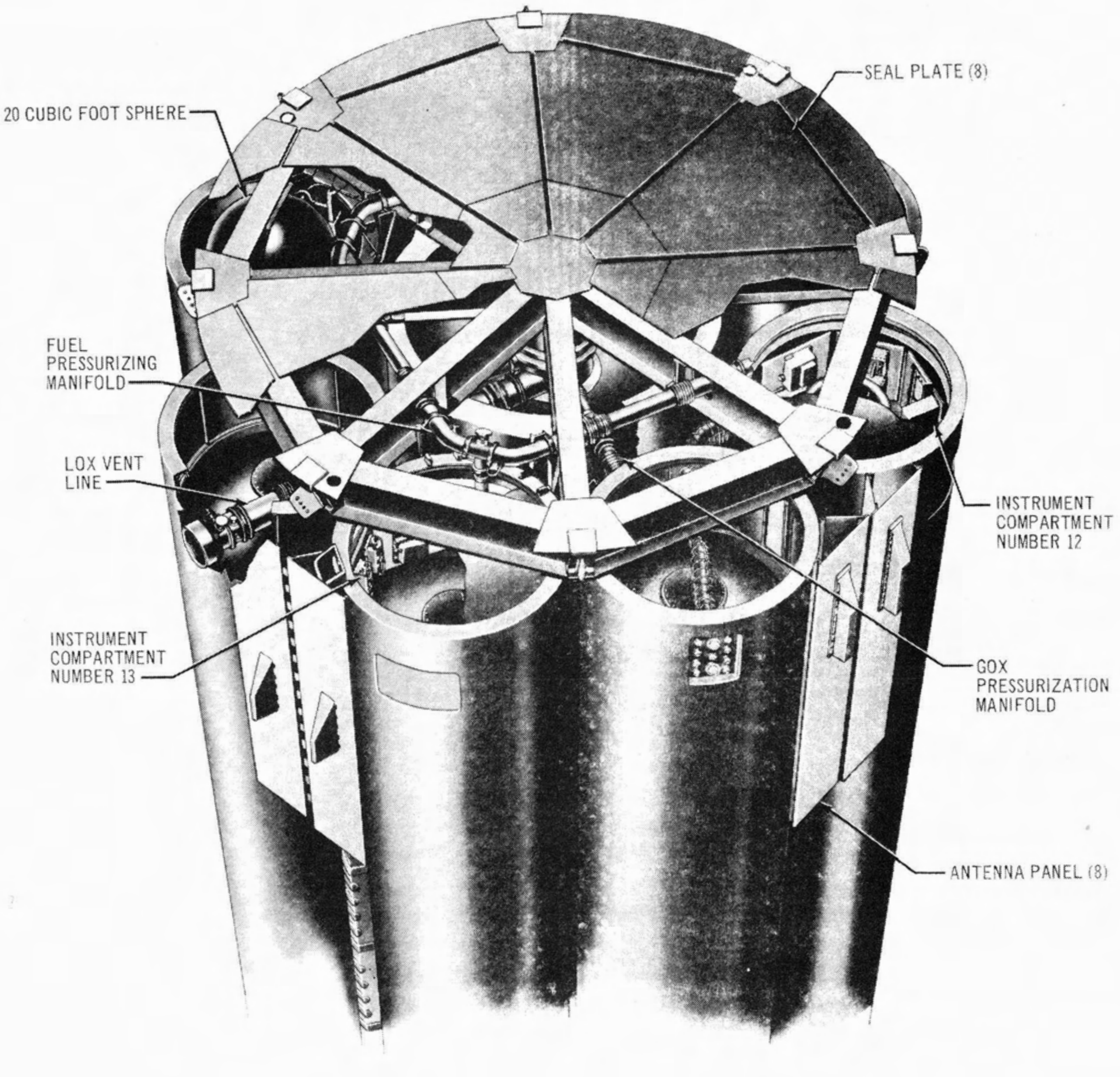

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FIGURE 16. SPIDER BEAM AND TOP TANK AREA

E. S-IVB STAGE

The S-IVB stage (Fig. 17), manufactured by Douglas Aircraft Company, is a self-supporting structure designed for utilization as the third stage of the Saturn V vehicle and adapted as the second stage of the Saturn IB vehicle. The stage, including the forward skirt and aft interstage assemblies, is 59.1 feet long and 260 inches in diameter.

Basically, the stage is a two-section tank structure to which the forward skirt assembly, aft skirt assembly, aft interstage assembly, the aft interstage fairing, and the thrust structure are attached. An insulated common bulkhead divides the tank structure into a forward LH_2 tank and an aft LOX tank. The internal surface of the tank cylinders features a milled waffle surface pattern. Access to the interior of the LH_2 tank is provided through a manhole in the top. Access to the interior of the LOX tank is provided through a detachable sump. A ring-type baffle is installed in the LOX tank to minimize sloshing. An external tunnel extending from the forward skirt assembly to the aft skirt assembly houses various intrastage tubing, cables, and lines from the cold helium spheres mounted inside the LH_2 tank.

1. Tail Area. The engine thrust structure (Fig. 17) is a truncated cone of reinforced skin and stringer construction. The large end of the cone is attached to the aft dome of the LOX tank. The engine, engine hydraulic actuating components, and a control pressure helium sphere are mounted on the thrust structure. The control pressure sphere supplies ambient helium at 3,000 psig for pneumatic operation of valves in the LH_2 and LOX systems, and supplies constant purge for the engine gearbox. Two doors provide access to the thrust structure through a trapezoidal opening.

The aft interstage (Fig. 17) is a cylindrical skin and external stringer structure located between the aft skirt field splice plane of the S-IVB and S-IB stages and the interface of the S-IVB and S-IB stages. The interstage serves to transmit structural loads between the stages and also provides an aerodynamic enclosure between the stages. There are provisions for eight equally spaced mounting points on a 220-inch diameter circle for the interface of the S-IB and S-IVB stages. Four retromotors are mounted on the aft interstage aft of the separation plane and at 90-degree intervals around the periphery. The retromotors and support bracketry are enclosed in aerodynamic fairings. The four solid propellant retromotors produce a retarding force on the S-IB stage to prevent S-IB/S-IVB interaction during separation. The retromotors ignite, during separation, 16 to 31 milliseconds after the shaped explosive charges are fired that cut the skin at the separation plane between the S-IVB and the S-IVB stage. A door located in the forward portion of the interstage provides personnel access for maintenance purposes. An aft interstage fairing is attached to the rear of the aft interstage. The fairing

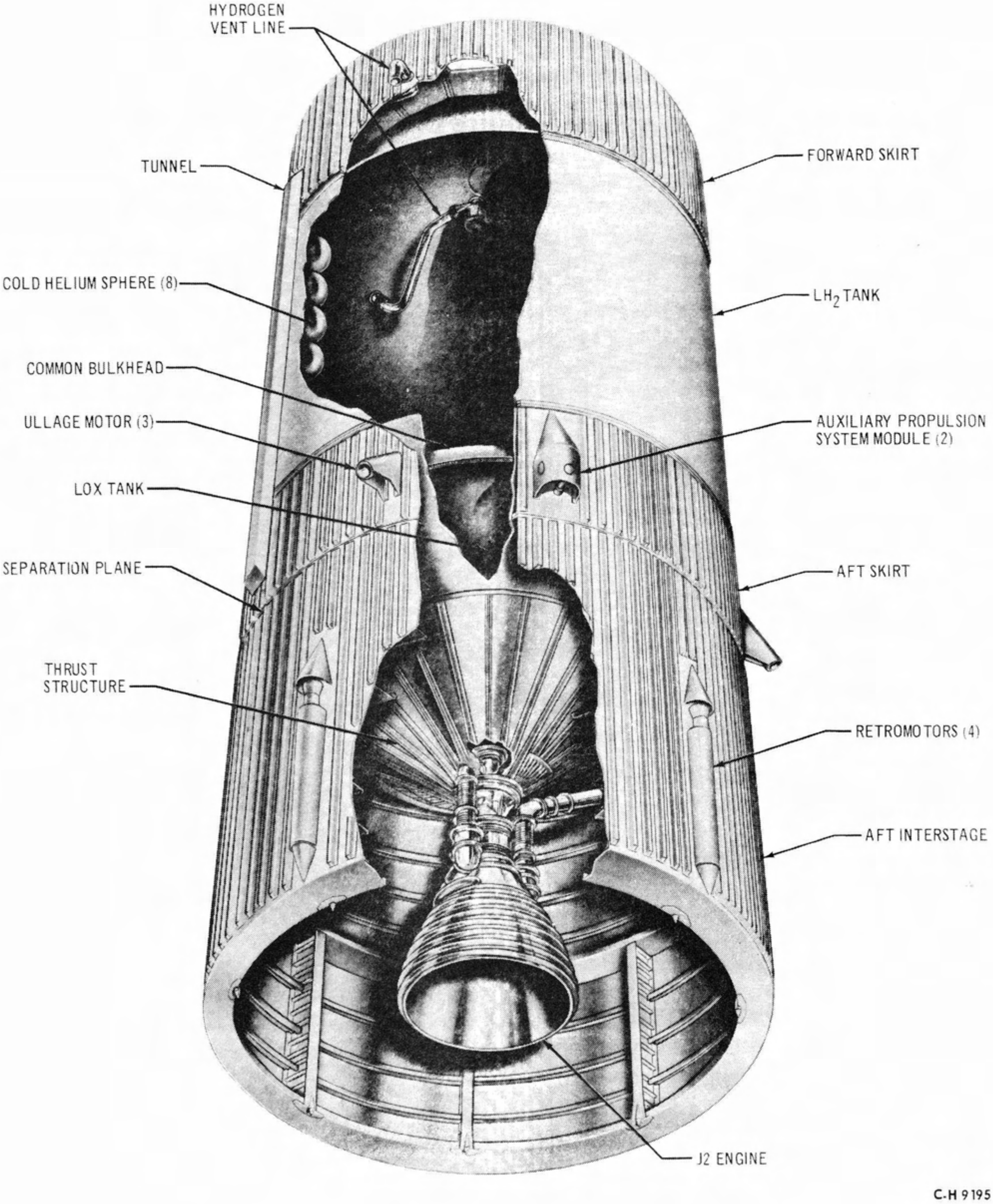


FIGURE 17. S-IVB STAGE

provides an aerodynamic sheath over the S-IB stage spider beam and the uppermost portion of the S-IB stage propellant container.

The aft skirt (Fig. 17) is constructed of aluminum with a skin and external stringer design. The aft umbilical plate, a hydrogen feed line fairing, three ullage rocket motors, and two auxiliary propulsion system (APS) modules are mounted on the aft skirt. Ullage motor firing is the first step in the separation sequence. The ullage motors impart forward acceleration when fired; this force settles the fuel to provide a positive turbopump head and aids S-IB/S-IVB stage separation. The APS consists of the two APS modules mounted 180 degrees apart on the skin. Each module contains three fixed storable-propellant-fueled engines arranged to control attitude in the pitch, roll, and yaw planes. The APS is controlled by the vehicle guidance computer in the instrument unit. The APS maintains roll control during S-IVB powered flight, and provides complete attitude control during earth orbiting and maneuvering exercises. The aft skirt structure is unpressurized and houses various electrical components of the propellant control system, engine control system, the auxiliary hydraulic pump motor, two batteries, and portions of the instrumentation and telemetry system.

2. Propellant Containers. The LH_2 container, formed by the forward end of the tank structure and the forward side of the common bulkhead, has a capacity of approximately 10,377 cubic feet. Inside surfaces of the LH_2 container have 3/4-inch polyurethane foam bonded to the walls. Glass cloth coated with polyurethane sealant covers the foam. Pipes and fittings are vacuum jacketed. Mounted inside the tank are fuel mass, temperature, and liquid level sensors for propellant utilization operation, propellant loading, and ground monitoring display. Eight cold-helium spheres are installed in the container to supply helium for inflight LOX tank pressurization. The cold helium is expanded by passing it through a heat exchanger in the J-2 engine turbine exhaust system. A screen at the LH_2 tank outlet provides vortex suppression and fuel filtering. Vent and relief valves are installed in the forward end of the container. LH_2 fill, drain, and replenishing are accomplished through one fill and drain valve located in the bottom of the container.

The LOX container, formed by the aft end of the tank structure and the aft side of the common bulkhead, has a capacity of approximately 2,828 cubic feet. The suction line is attached to the sump, and an antivortex screen is mounted in the sump. LOX fill, drain, and replenishing are accomplished through one fill and drain valve located on the bottom of the container. Vent and relief valves are installed in the forward end of the container. Temperature, mass, and liquid level sensors are mounted in the container for propellant management.

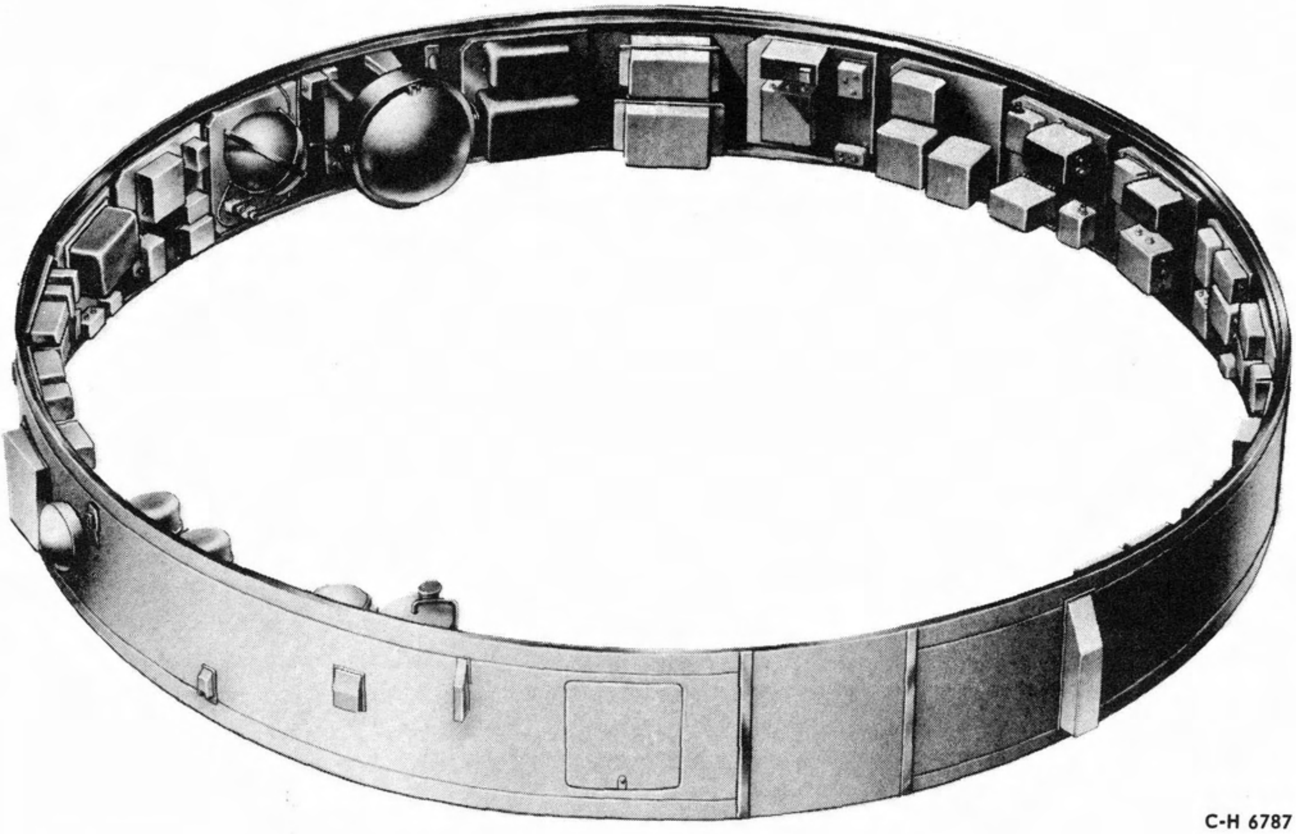
3. Forward Skirt. The forward skirt is a 260-inch-diameter, 122-inch-long cylinder of typical skin and external stringer construction. The skirt incorporates provisions for mounting the Instrument Unit. Cold plates are mounted to the walls of the skirt. Instrumentation, antennas, batteries, and other types of equipment are mounted to the plates. Environmental conditioning for the instrumentation is accomplished by pumping liquid coolant through the cold plates from the ground support instrument unit thermal conditioning system. The forward skirt contains the umbilical plate for the hydrogen vent line and electrical umbilicals. The telemetry antennas are also mounted on the skirt. Provisions for installing two retromotors are incorporated in the skirt, although such motors will only be installed in conjunction with a three-stage configuration of the Saturn IB vehicle. Access to the forward skirt is through the access door in the instrument unit. Mounting for a removable work platform is provided in the skirt.

F. INSTRUMENT UNIT

The Saturn IB instrument unit (Fig. 18) is an unpressurized, cylindrical, load-supporting structure of sandwich-type bonded construction 260 inches in diameter and 36 inches long. The structure is constructed in three 120-degree segments, each having a forward and aft interstage connecting ring segment. These three segments are assembled at the launch complex. Mounted on the interior skin are honeycomb panel cold plates to which is mounted the electrical and electronic equipment. Environmental conditioning is provided by a thermal conditioning system that pumps a water-methonal mixture through the cold plates. Prelaunch cooling is accomplished using ground support equipment. Inflight conditioning is accomplished by the onboard closed-loop conditioning system that incorporates an electric motor-driven pump and a heat exchanger to complete the refrigeration cycle.

The instrument unit houses an electrical system, instrumentation system, radio frequency system, environmental control system, the emergency detection system, and the guidance and control system.

The guidance, control, and monitoring systems govern performance of the vehicle throughout a major portion of its mission. Instrument unit control begins at liftoff and includes injection of the combined S-IVB stage, instrument unit, and Apollo spacecraft into earth orbit, and extends through participation in initial orbital maneuvers. This period includes the following phases of flight: first stage powered flight, first stage separation, second stage powered flight, injection into earth orbit, earth orbital coast stabilization, spacecraft turn-around and docking maneuver, and through spacecraft withdrawal from the remainder of the launch vehicle in earth orbit. The instrument unit ceases functioning when it is jettisoned in conjunction with the S-IVB stage at the conclusion of the aforementioned maneuver. The



C-H 6787

FIGURE 18. INSTRUMENT UNIT

guidance and control equipment includes an ST-124 (four gimbal gyro-stabilized) inertial guidance platform, the platform electronic box, a guidance signal processor, a digital computer, and a programming device. A gaseous nitrogen air-bearing supply is used in conjunction with the inertial platform.

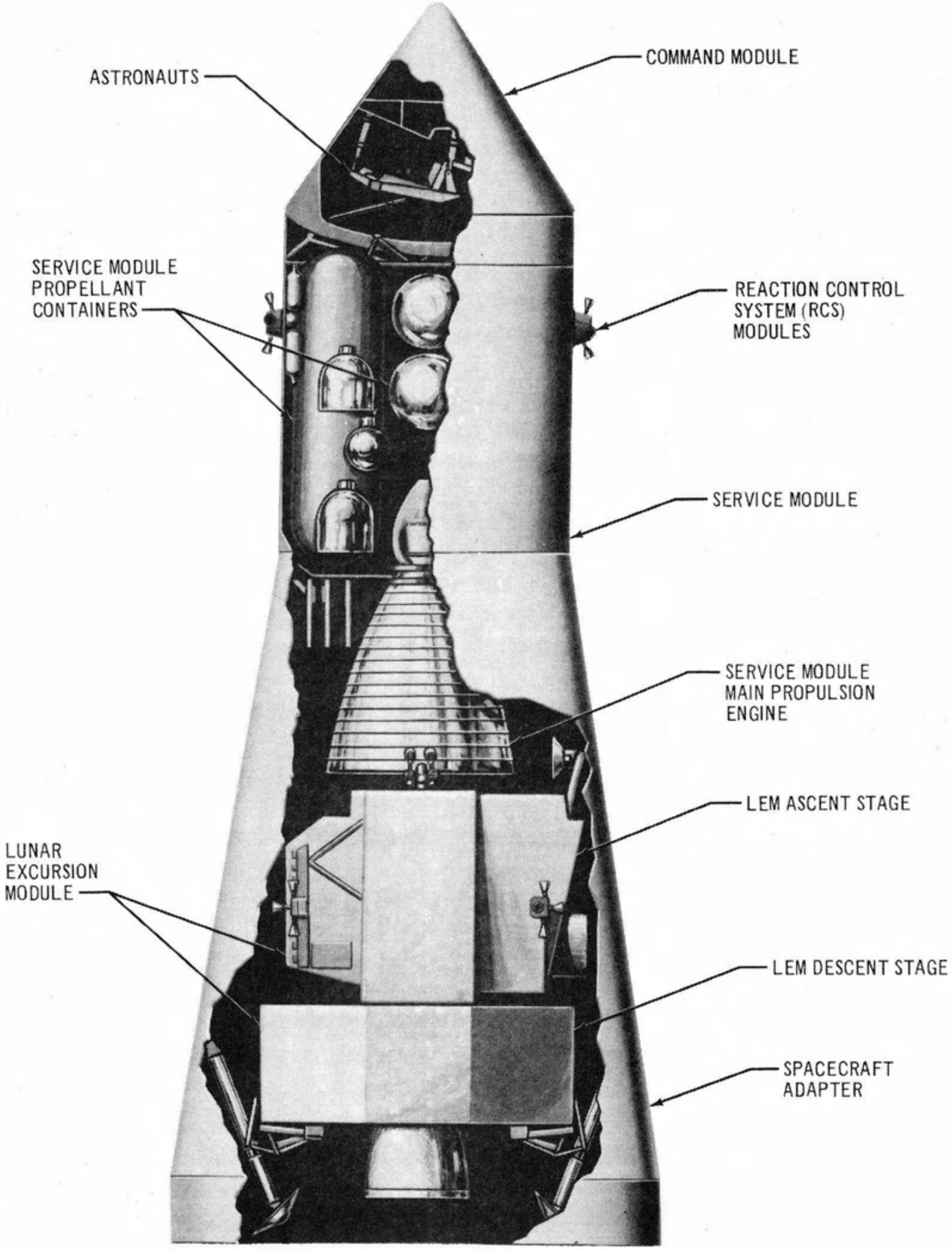
G. PAYLOAD

Figure 19 of the Apollo spacecraft illustrates in cutaway view the command module (CM), service module (SM), lunar excursion module (LEM), and the spacecraft adapter (SA), each of which is a major component of the Apollo spacecraft. Not shown in this view is the launch escape system, also a major component of the spacecraft, which is attached to the forward end of the command module. The CM contains the three astronauts and a majority of the spacecraft control equipment. The SM provides propulsion for the combined CM and SM in space. In the Saturn IB/Apollo earth orbital test program, the SM main propulsion engine will be tested and will be utilized to propel and maneuver the CM/SM combination into the proper position for reentry of the

CM and its astronaut crew into the earth's atmosphere. The test program will evaluate the SM for future use in the Saturn V program. In the Saturn V program, the SM propulsion system will be used to make mid-course corrections of the spacecraft enroute to the moon, to propel the spacecraft into proper launch orbit upon arrival at the destination, and to return the CM, containing the astronauts, toward the earth in the final phases of the lunar mission. The LEM will be tested during the Saturn IB/Apollo earth orbit test program. The tests will evaluate the LEM for future use in the Saturn V program. During the lunar missions of the Saturn V program, the LEM will be utilized in the following manner. The LEM (ascent and descent stages in combination) will land astronauts on the lunar surface for exploration and afterwards will return them (in the LEM ascent stage) to the CM/SM combination orbiting overhead around the moon. Upon completion of this rendezvous and transfer of the astronauts back into the CM, the LEM (ascent stage) will be jettisoned to orbit around the moon. The CM/SM will propel the astronauts back toward the earth. Each of the aforementioned Apollo spacecraft maneuvers, required for the lunar mission of the Saturn V program, will be executed during the earth orbital coast period as part of the Saturn IB program. Thorough testing of the Apollo spacecraft systems' capabilities will be performed during the earth orbital coast period. The configuration of the LEM shown in this illustration is an early design. This LEM early design has a general "helicopter bubble" forward face of the ascent stage. The ascent stage is designed to ascend from the moon after lunar exploration by the astronauts (in the Saturn V program). The LEM descent stage is designed to descend from lunar orbit and land upon the lunar surface during the Saturn V program. The LEM descent stage will be left behind on the moon when the astronauts return to earth. Extensive development tests and redesign have resulted in enlargement of the S-IVB stage propellant containers. This enlargement has necessitated folding the LEM descent stage landing gear for compactness of storage inside the spacecraft adapter. The SM main propulsion engine and the fuel and oxidizer propellant containers are also illustrated. Two of the four reaction control system (RCS) modules are shown. Each of these four modules consists of four reaction jets which will be utilized to provide maneuvering capability and attitude control in space. Expulsion of gas through these RCS jets will provide the pulsed thrust vector control of the CM/SM combination which will be necessary to effect precise direction and stability.

H. PROPELLANT DISPERSION SYSTEM (DESTRUCT SYSTEM)

The primary purpose of the range safety command destruct system is to provide a positive means for terminating the vehicle flight upon command from the ground.



C-H 9200

FIGURE 19. APOLLO PAYLOAD

Range safety requirements specify that each missile on the Atlantic Missile Range (AMR) must have two separate and independent emergency methods for terminating a flight, in the event of a vehicle malfunction. Vehicles launched at elevation angles greater than 45 degrees above the horizon (the Saturn IB is in this category) must contain two UHF radio command systems that are compatible with the dual command transmitters located on the range. The only items that may be common to the two systems are the antennas, the cabling, and the destruct package. Each airborne system (there is one for each of the booster stages) consists of command antennas, command destruct receivers, audio decoder, destruct system, and associated wiring. These provide the means for engine cutoff, arming of the destruct system for vehicle destruction, and propellant dispersion.

The destruct commands are transmitted by frequency-modulating the command transmitters (located at the launch site) with selected combinations of audio tones. This frequency-modulated carrier is received and demodulated by each of the command receivers. The recovered audio tones are then applied to the decoder, where they are separated according to frequency, to energize the proper combination of relays. The proper combination of relays completes the circuitry for execution of the desired command that initiates the engine cutoff and destruct sequence. A time delay between engine cutoff and destruct, required for escape of manned capsules and inflight charging of the EBW firing unit, is provided by a timer in the Range Safety Officer's console.

I. EMERGENCY DETECTION SYSTEM

An emergency detection system (EDS) has been developed to protect the astronauts in the event a malfunction should threaten loss of the Saturn IB space vehicle. The EDS (Fig. 20) is designed to accomplish the following functions: (1) detect equipment malfunctions, failures, and impending resultant emergencies, (2) evaluate the possible and probable consequences of these adverse conditions, (3) issue warning signals to the astronauts and to the personnel at ground monitoring stations, and (4) under certain circumstances, initiate action to protect the astronauts by ejecting them in the CM away from the launch vehicle. The evaluation of onboard vehicle irregularities is divided into two basic categories for the purpose of classifying EDS reaction. These two subdivisions are: (1) those which consist of, or will precipitate, 'critical failures,' and (2) those which consist of, or will precipitate, 'catastrophic failures.' 'Critical failures' are those which will cause serious limitations to the capability of the vehicle to accomplish its mission. 'Catastrophic failures' are those which are certain to result in destruction of the vehicle and for which the danger is imminent. 'Critical failures' may create conditions which later may degenerate into more serious conditions and culminate in the eventual loss of the vehicle. Because of a certain inherent time

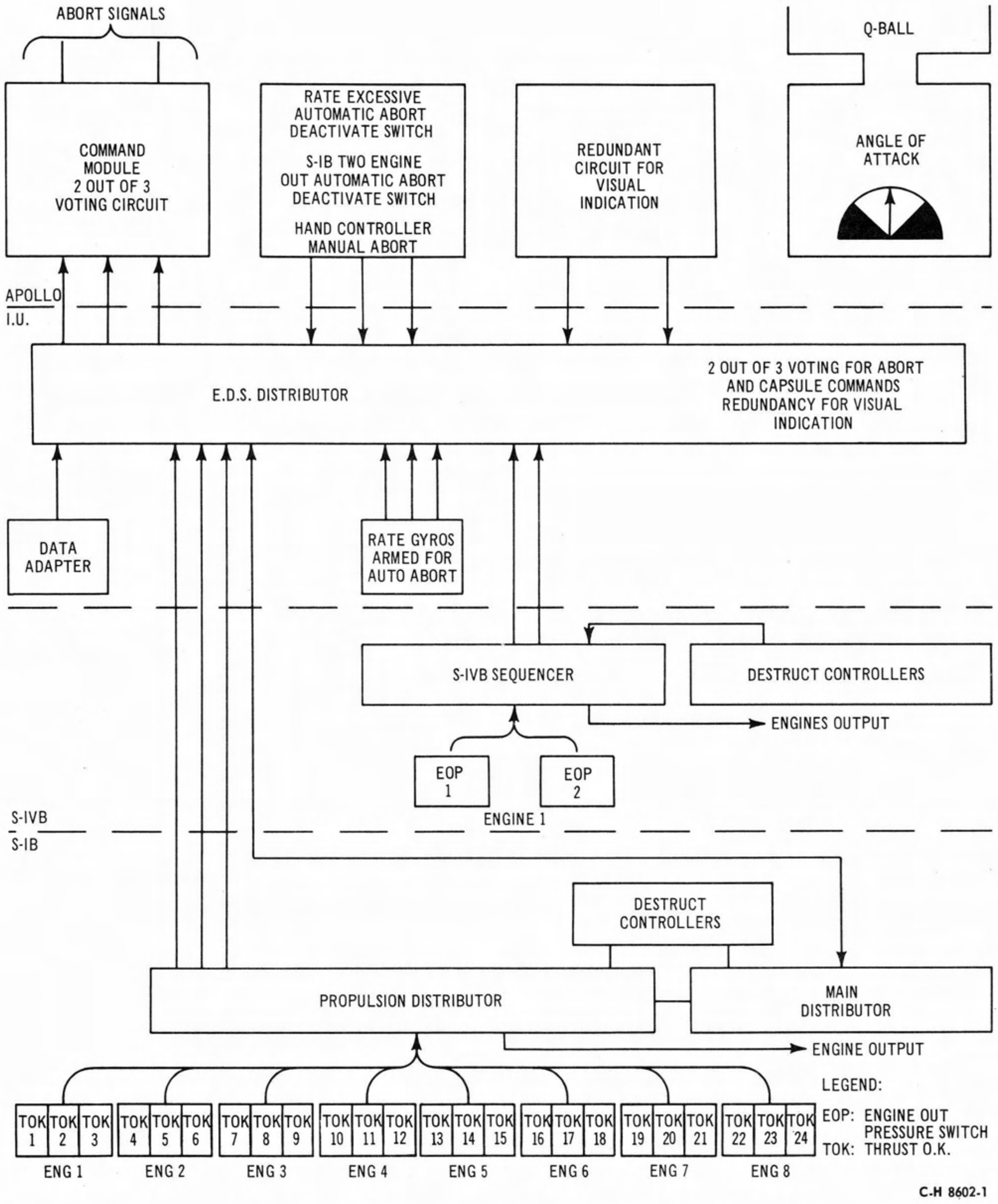


FIGURE 20. BLOCK DIAGRAM SATURN IB EDS

asset, 'critical failures' are susceptible to human evaluation as to the extent of their effects and as to the urgency of their demands.

The EDS provides manually initiated abort action when time permits, and automatic-initiated abort for 'catastrophic failures.' The EDS thereby takes advantage of the superior assets of onboard human reasoning and reaction by the astronauts in a highly capable man-machine system. The EDS likewise protects the astronauts by instantaneous automatic abort initiation when time is not available for human decision and action. Automatic abort conditions result if vehicle angular overrate occurs or loss of thrust of two or more engines on the S-IB stage is indicated. During both automatic and manual abort conditions, an emergency signal is transmitted to the EDS display panel in view of the astronauts in the CM. The signal display is 'advisory only' to the astronauts during automatic abort conditions. Under manual abort conditions, the astronauts are given the option to continue the mission or to initiate the abort sequence and thus terminate the mission in accordance with their own judgment. Information generated by the EDS is telemetered to ground monitoring stations. The ground operating personnel may thus assist in evaluating the factors involved in 'critical failure' conditions wherein manual abort may be required.

Malfunction and failure sensing elements of the EDS are located throughout the vehicle. The central receiving, evaluating, control, and distributing network elements are located in the instrument unit. Typical of this latter group is the EDS distributor. Signals representative of space vehicle performance parameters are supplied to this distributor from strategically important positions throughout the vehicle. The EDS distributor, in turn, routes the signals into appropriate paths for comparison, evaluation, display, and action initiation. The status of the following performance parameters are displayed on the astronaut's panel: (1) Engine status in S-IB stage, (2) Engine status in S-IVB stage, (3) Guidance failure indication, (4) Vehicle angle of attack, and (5) Vehicle angular motion rate.

The EDS includes an angular overrate device termed the rate package. The rate package measures the angular rates of displacement of the space vehicle from null positions in the roll, pitch, and yaw planes. The rate package will consist of nine rate gyros, three of which are mounted in each of the three planes of motion. Utilization of three rate gyros for measurement of movement rate in each plane provides redundancy and reliability for these extremely important functions. The same rate gyros are utilized for position and stability control of the vehicle during normal flight. Automatic abort is initiated if at least two of the three rate gyros sensing any one plane of motion (roll, pitch, or yaw) indicate that vehicle rates are excessive during S-IB stage powered flight. Under such excessive rate conditions automatic abort is mandatory if dictated by mission rules. Manual deactivation of this automatic abort feature is possible after completion of the S-IB stage powered flight and commencement of the period of S-IVB stage powered flight. At this time the Saturn IB vehicle will have reached an altitude of approximately 42 nautical miles. At such an altitude the vehicle has sufficient space in which to maneuver in the event of erratic performance. Also, from this altitude the astronauts have adequate time to escape should the vehicle lose power and begin descent. The danger of fire or explosion will still be present, but this danger will be greatly minimized after successful completion of the first stage separation procedure. The exact time at which the automatic abort feature may be deactivated is determined by the requirements of the individual mission for each vehicle. A single overrate light will be energized on the display panel before the astronauts in the CM whenever rates of motion are exceeded in any plane. The light will be energized by a discrete signal from the sensors in the rate package. The light will advise the astronauts of overrate conditions for use in making decisions regarding manual abort after deactivation of the automatic abort circuitry. During S-IVB stage powered flight, abort because of overrate conditions will be initiated manually. The limits may be varied to accommodate the conditions expected during each particular flight.

The loss of thrust from any two of the eight H-1 engines of the S-IB stage initiates automatic abort. For special missions the astronauts are provided with the means of bypassing this S-IB stage engine failure automatic abort feature. Back-up capability for deactivation of the engine failure automatic abort capability is provided in the Saturn IB launch vehicle sequencer.

GLOSSARY

Item	Definition
abort	(1) To terminate, or to limit the objectives, as a consequence of a malfunction or other unscheduled circumstance. (Relates to a flight mission, a development test, etc.) (2) A mission, test, etc., that is aborted.
AFRM	"Airframe." Denotes a flight-weight module of the Apollo Spacecraft, manufactured with hard tooling (i.e., nonimprovised tooling; tooling in which major changes are not anticipated), and equipped with such spacecraft systems as necessary to accomplish the assigned mission. Antonym: boilerplate.
AMR	Atlantic Missile Range. The Cape Kennedy, Florida, facilities of the Atlantic Missile Range include the launch complexes from which the Saturn-Apollo space vehicles are launched.
Apollo	The designation of the project and the associated spacecraft by means of which a manned lunar landing is to be accomplished within the present decade. In Greek and Roman mythology, Apollo is the god of prophecy, as well as the god of music, poetry and medicine.
attitude	The angular position of the space vehicle with respect to a set of space-fixed coordinate axes.
azimuth	The angular distance, expressed in degrees, measured clockwise, between the direction of true North (in the Northern Hemisphere) or South (in the Southern Hemisphere) and the direction of flight.

Item	Definition
boilerplate	Denotes a simulated module of the Apollo Spacecraft, manufactured with soft tooling (i. e., improvised or relatively inexpensive temporary tooling), and equipped with such spacecraft systems as necessary to accomplish the assigned mission in the development of the spacecraft design. Antonym: AFRM.
canted	In reference to a propulsion engine of a Saturn launch vehicle: installed in the launch vehicle stage in such a manner that the nominal line of action of the thrust force of the engine is not parallel to the fore-and-aft axis of the stage.
center of gravity (CG)	The point in the space vehicle at which the entire mass of the vehicle can be assumed to be concentrated, for the purpose of convenience in such calculations as the motion of the vehicle along its trajectory. (The CG of any part of the vehicle, such as an individual stage of the launch vehicle, has comparable meaning relative to that part.) The location of the CG changes as fuel or other stores are expended.
CG	Center of gravity.
circumlunar	"Around the Moon." Denotes a mission in which a spacecraft circles the Moon one or more times, without a lunar landing, and returns to Earth.
CM	Command Module.
Command Module (CM)	The part of the Apollo Spacecraft which serves as a command center, living quarters and environmental protection for the three-man crew. The Command Module re-enters the Earth's atmosphere and is recovered at the conclusion of an Apollo mission.
docking	The maneuver that is performed when the Command Module and the Lunar Excursion Module of the Apollo Spacecraft are aligned while physically separate from each other in Earth orbit or in

Item	Definition
	lunar orbit; are brought closer together until they are in contact; and are locked together to permit the transfer of crew members through connecting hatches.
drogue parachute	The relatively small parachute that is deployed from the Command Module of the Apollo Spacecraft for the purpose of applying a force which suppresses perturbations in the attitude of the Command Module, and which retards the speed of the Command Module. The drogue parachute is deployed after the Command Module has passed through the critical aerodynamic heating range on re-entry into the Earth's atmosphere, and is jettisoned before the main parachutes are deployed from the Command Module.
Earth transfer trajectory	The flight course that is followed by the Apollo Spacecraft in traveling from the vicinity of the Moon to the vicinity of the Earth.
EBW	Exploding Bridge Wire.
ESE	Electrical Support Equipment.
exploding bridge wire	A wire resistance element that breaks up explosively when a suitable pulse of electrical energy is applied to it. This action ignites an explosive charge in a detonator unit.
first stage	The aftermost stage of the launch configuration of a Saturn launch vehicle. The stage which is first to provide propulsive thrust for the space vehicle.
GFE	Government-Furnished Equipment.
GH_2	Gaseous Hydrogen (as distinguished from liquid Hydrogen).
gimbaled	(1) Mounted in gimbals. (2) Caused to pivot about the axes of the gimbals (a colloquialism).

Item	Definition
gimbals	The mechanical mounting for a movable propulsion engine in a Saturn launch vehicle stage or the Apollo Service Module. The gimbals permit the engine to pivot about two mutually perpendicular axes that lie in a plane that is either normal to or nearly normal to the longitudinal axis of the vehicle. Some or all of the propulsion engines in each Saturn stage and the Apollo Service Module are so mounted, so that the direction in which the thrust force acts can be varied as necessary to steer and stabilize the space vehicle or the spacecraft.
GN_2	Gaseous Nitrogen (as distinguished from liquid Nitrogen).
GOX	Gaseous Oxygen (as distinguished from liquid or solid Oxygen).
GSE	Ground Support Equipment.
hypergolic	In reference to a pair of liquid propellants: capable of igniting spontaneously when brought into contact.
IMCC	Integrated Mission Control Center. The ground organization located near Houston, Texas, whose responsibility is overall mission control and coordination. The IMCC utilizes the services provided to it by the Launch Control Center, the Global Tracking and Communications Networks, the Computer Complex at Houston, the Recovery Control Centers and forces, and the data reduction facilities.
Instrument Unit (IU)	The forward section of the operational Saturn I, the Saturn IB and the Saturn V launch vehicles. Houses guidance and control and telemetry equipment, and provides mounting points for Apollo payload.
IU	Instrument Unit.

Item	Definition
launch complex	An area which contains the facilities that are needed for the preparation and launch of a Saturn-Apollo space vehicle; part of the Atlantic Missile Range.
Launch Escape System (LES)	A special-purpose propulsion system installed on the Command Module, capable of lifting the Command Module free of the rest of the space vehicle for parachute descent, to preserve the lives of the spacecraft crew in the event of a serious emergency during the early part of a mission. The Launch Escape System is jettisoned during the course of a normal mission.
launch vehicle (LV)	The two-stage or three-stage Saturn rocket booster which lifts an Apollo payload to high altitude and places it on a specified flight course for the performance of an Apollo mission.
LEM	Lunar Excursion Module.
LES	Launch Escape System.
LH_2	Liquid Hydrogen.
liftoff	(1) The action of the space vehicle in starting to rise from the launch platform. (2) The instant in time at which liftoff occurs, when the velocity of the vehicle changes from zero to an infinitesimally small, positive value.
LOC	Launch Operations Center, Cocoa Beach, Florida, the National Aeronautics and Space Administration center which is responsible for launching the Saturn-Apollo space vehicles and obtaining flight data.
LOR	Lunar-Orbit Rendezvous.
LOX	Liquid Oxygen.

Lunar Excursion Module (LEM)	The part of the Apollo Spacecraft which lands on the Moon. The Lunar Excursion Module is a self-contained vehicle which enables two members of the three-man spacecraft crew to descend from the lunar-orbiting spacecraft, land on the Moon, make observations and collect specimens, take off and rejoin the spacecraft.
Lunar-Orbit Rendezvous (LOR)	The technique by means of which the ascent stage of the Lunar Excursion Module, rising from the surface of the Moon after completion of the lunar landing phase of the mission, is caused to intercept the spacecraft in its circular lunar orbit, for the purpose of docking and enabling crew members to return to the spacecraft from the Lunar Excursion Module. The selection of the LOR technique in preference to alternative techniques was a major decision in the Apollo project.
lunar transfer trajectory	The flight course that is followed by the Apollo Spacecraft in traveling from the vicinity of the Earth to the vicinity of the Moon. The Apollo Spacecraft is injected into a lunar transfer trajectory from an Earth parking orbit by the Saturn launch vehicle.
LV	Launch vehicle.
Michoud Operations	The manufacturing facility operated by Marshall Space Flight Center near New Orleans, Louisiana, at which first stages of Saturn launch vehicles, and other Saturn items, are manufactured.
midcourse	The middle region of a lunar transfer trajectory or Earth transfer trajectory.
midcourse correction	A change in the speed or direction of the Apollo Spacecraft which is effected in midcourse along a lunar transfer or Earth transfer trajectory for the purpose of ensuring that the spacecraft will arrive at a desired position in relation to the Moon or the Earth.

Item	Definition
mission	The clearly-defined task that is assigned to a Saturn-Apollo space vehicle. The task typically has multiple objectives which are identified as either the primary or the secondary objectives of the mission.
MSC	Manned Spacecraft Center, Houston, Texas, the National Aeronautics and Space Administration center which is responsible for the Apollo Spacecraft and the associated Support Equipment.
MSFC	George C. Marshall Space Flight Center, Huntsville, Alabama, the National Aeronautics and Space Administration center which is responsible for the Saturn launch vehicles and the associated Support Equipment.
MTF	Mississippi Test Facility, the National Aeronautics and Space Administration test facility at which flight stages of Saturn launch vehicles undergo static testing and acceptance testing.
NASA	National Aeronautics and Space Administration, the civilian agency of the Executive Branch of the Federal Government which is responsible for the execution of the National Space Exploration Program, including a manned lunar landing during the present decade. The latter is to be achieved through the Saturn-Apollo project.
nautical mile	Unit of measure equal to 6076.10333 feet, or 1.15077 statute miles, or 1.852 kilometers.
OMSF	Office of Manned Space Flight, Washington, D.C., the office of the National Aeronautics and Space Administration which is responsible for the over-all direction of the Saturn-Apollo project.
parking orbit	The circular orbit around the Earth or Moon in which an Apollo Spacecraft on a lunar mission coasts (i.e., is 'parked') while the spacecraft, the crew and the navigation are checked out prior to the departure of the spacecraft on a transfer

Item	Definition
	trajectory. The spacecraft is injected into the Earth parking orbit, and later into the lunar transfer trajectory, by its Saturn launch vehicle.
payload	The item(s) that are lifted by a SATURN launch vehicle, exclusive of the systems of the launch vehicle itself, in support of the Apollo project.
PERT	"Program Evaluation and Review Technique." A computer technique which picks a limiting path through an array of identifiable activities that make up a complex project such as the Saturn project, and indicates such information as (a) the overall time required to complete the project, under the envisioned plan of work, and (b) the activities which limit the progress of the project, from the standpoint of time necessary for their completion.
pitch	Rotational motion of the space vehicle about its center of gravity (CG) which causes the nose of the vehicle to rise or drop relative to the flight path. Positive pitch is taken to be a nose-up motion.
pitch plane	The geometric plane in which pitch occurs.
Position	One of four locations, designated by Roman numerals, around the circumference of the body of the launch vehicle. Position I lies in the pitch plane, so located that the vehicle pitches down (pitches negatively) over Position I. Positions II, III and IV are located 90°, 180° and 270° clockwise from Position I, as viewed from the aft end of the vehicle, looking forward. The four Positions are established to aid in correlating physical locations within the launch vehicles. The locations of the Positions are consistent among all of the launch vehicles and their stages.

Item	Definition
propellant	A material that is burned in a propulsion engine of a Saturn launch vehicle stage or the Apollo Service Module to provide propulsive thrust. The term "propellant" includes both fuel and oxidizers, the latter being materials that combine chemically with the former to sustain combustion. A propellant may be a solid material, as well as a pair of liquids.
re-entry	The penetration of the Earth's atmosphere by an Apollo Command Module which previously was lifted out of the atmosphere by a Saturn launch vehicle. In particular, that part of the penetration in which the rise of the temperature of the surface of the Command Module, due to aerodynamic heating, is critically high.
recovery	The scope of action associated with locating the Command Module of an Apollo Spacecraft after it has landed on the surface of the Earth, taking physical possession of it, and transferring it and its crew to a sheltered location.
retromotor	A forward-facing rocket motor that is fired during the staging period to ensure positive separation of a stage of the Saturn-Apollo space vehicle.
roll	Rotational motion of the space vehicle about the fore-and-aft axis that passes through the center of gravity (CG) of the vehicle. Positive roll is taken to be roll that appears to be clockwise when viewed from the aft end of the vehicle, looking forward.
Saturn	The designation of the project and the launch vehicles by means of which Apollo Spacecraft will be placed in Earth orbit and on lunar transfer trajectories for the performance of Apollo missions. Saturn is the second of the planets of our solar system, from the standpoint of size, following Jupiter, the largest.

Item	Definition
SC	Spacecraft.
SE	Support Equipment.
second stage	The stage which is immediately forward of the first stage of a Saturn launch vehicle. The stage which provides propulsive thrust after the first stage is shut down and separated.
separation	Staging.
Service Module (SM)	The part of the Apollo Spacecraft which carries equipment and stores that support the operation of the Command Module, and the main propulsion engine for the Apollo Spacecraft. The Service Module remains with the Command Module throughout most of an Apollo mission and is jettisoned shortly before the Command Module re-enters the Earth's atmosphere.
SM	Service Module.
SOX	Solid (i.e., solidified) Oxygen.
spacecraft (SC)	The Apollo Spacecraft, a self-contained vehicle which, after having been placed on a lunar transfer trajectory by a Saturn launch vehicle, conveys a three-man crew to the vicinity of the Moon, permits the descent of two crew members to the surface of the Moon, and returns the crew safely to Earth. The term applies also to Apollo configurations launched on missions of more limited scope than the lunar landing mission. The complete Apollo Spacecraft consists at launch of a Launch Escape System, a Command Module, a Service Module, an Adapter and a Lunar Excursion Module.
space vehicle (SV)	The Saturn-Apollo space vehicle, which consists of a Saturn launch vehicle in combination with an Apollo Spacecraft.

Item	Definition
specific impulse	A measure of rocket propulsion engine performance, the ratio of the thrust force to the time rate of propellant flow. Conventional units: seconds.
stage	A section of the Saturn launch vehicle which has a self-contained propulsion system and which is separated from the rest of the Saturn-Apollo space vehicle after having fulfilled its function of propelling the space vehicle during a specified part of the mission. Saturn I and Saturn IB are two-stage launch vehicles. Saturn V is a three-stage launch vehicle.
staging	The sequence of events which effects the shutdown of the propulsion engines in a stage of a Saturn launch vehicle, its physical separation from the next stage, and the starting of the propulsion engine(s) of the latter stage.
staging period	The interval of time that elapses between the initiation of the first event of the staging sequence and the completion of the last event.
SV	Space vehicle.
third stage	The stage which is immediately forward of the second stage of a Saturn launch vehicle. The stage which provides propulsive thrust after the second stage is shut down and separated.
time tilt	A function performed by the guidance and control system of the Saturn launch vehicle, whereby the space vehicle is caused to pitch over (i. e., to "tilt") at a given rate after liftoff, during the first-stage burning period, in order to change the direction of flight from vertical ascent to the desired trajectory.
transearth trajectory	An Earth transfer trajectory.

Item	Definition
translunar trajectory	A lunar transfer trajectory.
torispherical	The shape of the domed end of a Saturn propellant container; formed by the combination of a segment of a toroid, which blends into the cylindrical body of the container, and a segment of a sphere, which blends into the toroid, forming a smooth, continuous curve.
ullage	The amount which a tank lacks of being full of a liquid propellant, in a stage of a Saturn launch vehicle.
ullage motor	A rocket motor that is fired prior to an inflight engine start, accelerating the Saturn-Apollo space vehicle in the direction of flight for the purpose of forcing the propellants into the aft ends of their tanks (i. e., causing the ullage to exist only at the forward ends of the tanks), to ensure that the propellants can flow uninterruptedly to the engine(s) to be started.
VEDS	Vehicle Emergency Detection System.
yaw	Rotational motion of the space vehicle about its center of gravity (CG) which causes the nose of the vehicle to swing right or left relative to the flight path. Positive yaw is taken to be yaw in which the nose swings to the right, as viewed while looking forward in the vehicle.